सत्यमेव जयते

MINISTRY OF RURAL DEVELOPMENT

# SPECIFICATIONS FOR RURAL ROADS

*(First Revision)*

*Published by:*
**Indian Roads Congress**
**New Delhi 2014**

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# FOREWORD

Rural Roads act as facilitators to promote and sustain agricultural growth, improve basic health, provide access to schools and economic opportunities leading to accelerated poverty reduction and socio-economic transformation. Therefore, as a part of country's broader poverty reduction strategy, Pradhan Mantri Gram Sadak Yojana (PMGSY) was launched on the 25th December, 2000 as a fully funded scheme by the Government of India. The programme aims at connecting every habitation that has a population of more than 500 persons (250 in case of Special Category States, hill States, desert areas, tribal areas and selected tribal and backward districts). Rural roads being a State subject, the implementation of the programme is the responsibility of the State Governments.

The Rural Roads Manual (IRC:SP:20-2002) was published by the Indian Road Congress (IRC), as the first technical intervention for Rural Roads. Subsequently, the National Rural Roads Development Agency (NRRDA), constituted for the purpose of providing technical and management support to the Ministry of Rural Development for implementation of the programme, developed a Standard Bidding Document and a Quality Assurance Handbook Vol-I & II. The Indian Roads Congress, on request of NRRDA, has further published Guidelines for the Design and Construction of Cement Concrete Pavements for Rural Roads (IRC-SP:62-2004), Guidelines for the Design of flexible Pavements for Low Volume Rural Roads (IRC SP-72:2007), Manual for Design, Construction & Maintenance of Gravel Roads (IRC SP: 77-2008) and Manual for Procurement and Contract Management of work.

On request of the NRRDA, the task of developing Standard Specifications for Rural Roads was undertaken by the IRC and the document was first published in 2004. Since then it has been extensively used by the Engineers. Contractors and others involved in the construction and maintenance of Rural Roads not only under the PMGSY but also under other size Schemes.

This edition is the first revision of the document entitled 'Specifications for Rural Roads'. During the last decade, significant developments have taken place in the Rural Roads sector and about 4 lakh km of rural roads have been constructed or upgraded under PMGSY alone. Experience gained, feedback received from the field engineers, revision of several IRC codes, development in construction practices and design has necessitated the revision of specifications for rural roads. Learning from past experiences of providing all weather connectivity, Government of India has allowed construction of long span bridges (upto 50 m in normal areas and 75 m in IAP areas from MoRD Programme Fund). This has led to the inclusion of specifications for relevant items of bridge construction in this document.

Moreover, in view of the increasing cost of construction of rural roads and scarcity of materials, Government of India has decided to mainstream the already available new technologies such as Cold Mix Technology, Waste Plastic Modified Bitumen, soil stabilized sub base and use of locally available marginal materials, industrial wastes, etc.

With significant improvement in connectivity of rural habitations through all weather roads and with growth in traffic, Government of India has recently launched a programme, PMGSY-II on cost sharing basis with State Governments, under which another 50,000 km of rural roads are proposed to be upgraded. Provision of proper road signs and other traffic control devices to improve road safety has also become important, in view of sharp increase in traffic in rural areas. Specifications relevant to Rural Roads have now been incorporated in this edition. In order to protect our environment, a separate Section on Environment and Social Safeguards, covering salient features of the environmental and social management framework has also been incorporated.

The work of revising the Specifications was taken up by the Indian Roads Congress at the request of the NRRDA. The edition, as first revision, is the result of the sustained and concerted efforts of the Experts, Scientists of CRRI, Officers of SRRDA's and Officers of NRRDA. I wish to express my gratitude to all of them and the Indian Roads Congress (IRC) for undertaking the assignment.

I also wish to place on record my special thanks to the Members of the Peer Review Committee of NRRDA for reviewing the revised edition and providing their guidance in the two workshops organized by NRRDA with participation of SRRDAs of the State Governments.

Feedback and suggestions for further improvement would be welcome from users of this edition.

**(Rajesh Bhushan)**
**(Director General, NRRDA)**
**Joint Secretary, Ministry of Rural Development**
**Government of India**

**New Delhi**
**January, 2014**

## PREFACE TO FIRST REVISION

The roads, particularly, the highways, are considered to be the lifeline of a country. Efficient road connectivity is an essential component not only for socio-economic growth of the region(s)/country but also helps in achieving balanced growth & inclusive growth. The world's biggest road development programme launched by the Government of India under the "Pradhan Mantri Gram Sadak Yojana" (PMGSY) provides for all weather road connectivity to the habitations in the rural and far-flung areas in the country. Simultaneously, under the programme, emphasis has been laid for well-engineered rural roads along with quality product deliverance. The construction of quality roads requires concerted actions on many fronts and to facilitate the same, the requirement is of concise and apt Specifications. Such Specification brings not only uniformity of approach but also quality in engineering & construction. It is on the strength of the document(s) such as Rural Roads Manual and other Codes and Guidelines of the IRC that the country could successfully embark upon these programmes.

On the request of National Rural Roads Development Agency (NRRDA), an arm of the Ministry of Rural Development, the Indian Roads congress (IRC) prepared and published Specifications for Rural Roads in August, 2004. This document is being used throughout the country for ensuring uniform construction standards & specifications. During the intervening period, a number of technological developments have taken place. Besides, various Codes/ Manuals/Guidelines/Specification, etc. have undergone revision based on the research work done in India & abroad as well as the experienced gained in execution of road projects, thereby necessitating the revision of specifications for rural roads.

Accordingly, on the request of the NRRDA, the IRC undertook the task of revision of MORD Specifications for Rural Roads. For this purpose, the IRC constituted a Working Group comprising of senior and experienced experts in various fields of roads and bridges:

1. Shri D.P. Gupta, Former DG(RD) & AS, MoRTH - Group Leader
2. Shri S.C. Sharma, Former DG(RD) & AS, MoRTH - Member
3. Shri R.S. Sharma, Former Chief Engineer, MoRTH - Member
4. Shri R.K. Jain, Former Chief Engineer, Haryana PWD - Member
5. Shri Arun Sharma, Former Chief Engineer, Himachal, PWD - Member
6. Shri Aditya Sharma, Associate Director, Gifford India Ltd - Member
7. Shri Goverdhan Lal Verma, Engg. & Planning Consultants - Member
8. Shri R.K. Saxena, Former Superintending Engineer, MoRTH - Member
9. Shri G.S. Khinda, Former Superintending Engineer, MoRTH - Member

Shri Rahul Patil, Assistant Director (Technical), Shri S.K. Chadha, Under Secretary and Shri S.K. Mishra (IRC) provided the secretariat support.

The Working Group prepared the draft revision of specifications taking due guidance from the latest version of MORTH Specifications for Road & Bridge Works, various

IRC Codes/Manuals/Guidelines/Specifications revised/published as also from BIS standards and international Codes of Practice.

The draft was reviewed by the Peer Review Committee constituted by the NRRDA. The Peer Review Committee comprise of the following:-

1. Shri Vishnu Shankar Prasad, Secretary General, IRC - Chairman
2. Dr. I.K. Pateriya, Director (Technical) & I/c Director (Projects-II) NRRDA - Member Secretary
3. Shri M.C. Boro, Commissioner, PWD (Roads), Assam - Member
4. Shri M.N. Nagabhushana, Flexible Pavement Division, CRRI - Member
5. Dr. Renu Mathur, Rigid Pavement Division, CRRI - Member
6. Dr. P. Lakshmy, Bridges/Cross Drainage Works Div, CRRI - Member
7. Shri Satish Sagar, CE (Retd.), Himachal Pradesh PWD - Member
8. Shri H.P. Shivhare, CE, RES, Madhya Pradesh - Member
9. Shri Mahesh M. Hiremath, COO, KRRDA, Karnataka - Member
10. Shri P.K. Pradhan, CE, RWD, Odisha - Member
11. Shri Kago Tabiyo, Ex. SQC, RWD, Arunachal Pradesh - Member
12. Chief Engineer, UPRRDA, Uttar Pradesh - Member
13. Chief Engineer MRRDA, Maharashtra - Member
14. Chief Engineer, PWD, Rajasthan - Member
15. Shri N.C. Solanki, Director (Projects-I), NRRDA - Member
16. Shri Prabha Kant Katare, Ex. Director (Projects- III), NRRDA - Member
17. Dr. D.T. Thube, Ex. Director (Projects- III), NRRDA - Member

The final drafts were subjected to discussion through two Workshops organized by NRRDA where the participants were from State Academic Institutions, State Rural Roads Development Agencies (SRRDA's), CRRI, Peer Review Committee, etc. The suggestions emerged from the Workshops, Peer Review Committee, Members & NRRDA were incorporated in the revised Specification.

While revising the Specifications, every effort has been made to bring out the best current practice(s). However, road design and construction technology is continuously progressing forward. Future development(s) in research and construction practices will undoubtedly make it necessary to update the Specifications on regular basis.

14/1/2014

New Delhi
January, 2014

**(Vishnu Shankar Prasad)**
Secretary General
Indian Roads Congress

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# ABBREVIATIONS

AASHTO = American Association of State Highway and Transportation Officials
ASTH = american society for testing of materials
BIS = Bureau of Indian Standards
BOQ = Bill of Quantities
CBR = Callifornia Bearing Ratio
CD = Cross-Drainage
CRMB = Crumb Rubber Modified Bitumen
cum = Cubic metre
g = Gram
GBFS = Ganulated Blast Furance Slag
GSB = Granular Sub-Base
GTS = Grand Triangulation Survey
h = Hour
IRC = Indian Roads Congress
Kg = Kilogram
Km = Kilometre
kN = Kilo Newton
1 = Litre
m = Metre
MB = Modified Binder
ml = Millitire
mm = Millimetre
MORD = Ministry of Rural Development
MORTH = Ministry of Road Transport & Highways
MPa = Mega Pascal
MS = Medium Setting
NRRDA = National Rural Roads Development Agency
OMC = Optimum Moisture Content
PMB = Polymer Modified Bitumen
RMB = Rubber Modified Bitumen
sqm = Square metre
SS = Slow Setting
UCS = Unconfined Compressive Strength
WBM = Water Bound Macadam
WMM = Wet Mix Macadam

## 100

# GENERAL

## 101 INTRODUCTION

These Specifications shall apply to all such rural road and bridge works as are required to be executed under the contract or otherwise directed by the Engineer-in-Charge (hereinafter referred to as 'the Engineer'). In every case, the work shall be carried out to the satisfaction of the Engineer and conform to the location, lines, dimension, grades and cross-sections shown on the drawings or as indicated by the Engineer.

The quality of materials, processing of materials as may be needed at site, salient features of the construction work and quality of work, measures for safety of workers and public and traffic arrangements during execution shall comply with the requirements set forth in the succeeding Sections. Where the drawings and specifications describe a portion of the work in only general terms, and not in complete details, it shall be understood that only the sound engineering practice is to prevail, materials and workmanship of the best quality are to be employed and the instructions of the Engineer are to be fully complied with. The Specifications for most of the items of work are based on the current Indian Roads Congress Specifications and Codes of Practice and MORTH Specifications for Road and Bridge Works.

A list of Indian Roads Congress Specifications and Codes of Practice and MORTH, MORD publications which have been made use of in the preparation of these Specifications is given at **Appendix-1**.

## 102 DEFINITIONS

The words like Contract, Contractor, Employer, Engineer (synonymous with Engineer-in-Charge), Drawings, Government, Department, Works and Work site used in these Specifications, shall be considered to have the meaning as understood from the definitions of these terms intended in the general conditions of contract.

The abbreviations IRC, IS, BS, and ASTM shall be considered to have the following meaning:

IRC : Indian Roads Congress.

IS : Indian Standards published by the Bureau of Indian Standards (erstwhile Indian Standards Institution).

BS : British Standards of the British Standards Institution.

ASTM : American Standards of the American Society for Testing and Materials.

## 103 TESTS AND SIEVE DESIGNATIONS

The tests and testing procedures referred to in the specifications shall conform to the relevant IS, BS or ASTM standards as indicated at appropriate places in the respective specifications and comply with the requirements laid down in the Quality Assurance Handbook for Rural Roads issued by the NRRDA, May 2007 and any amendments issued by the NRRDA.

A list of these standards with their full title and the year of publication applicable is included at **Appendix-2**.

The sieve designations referred to in the specifications correspond to those specified in IS:460 (Parts 1 and 2).

The various elements in the cross-section of road referred to in these Specifications are shown in **Fig. 100.1 and 100.2**.

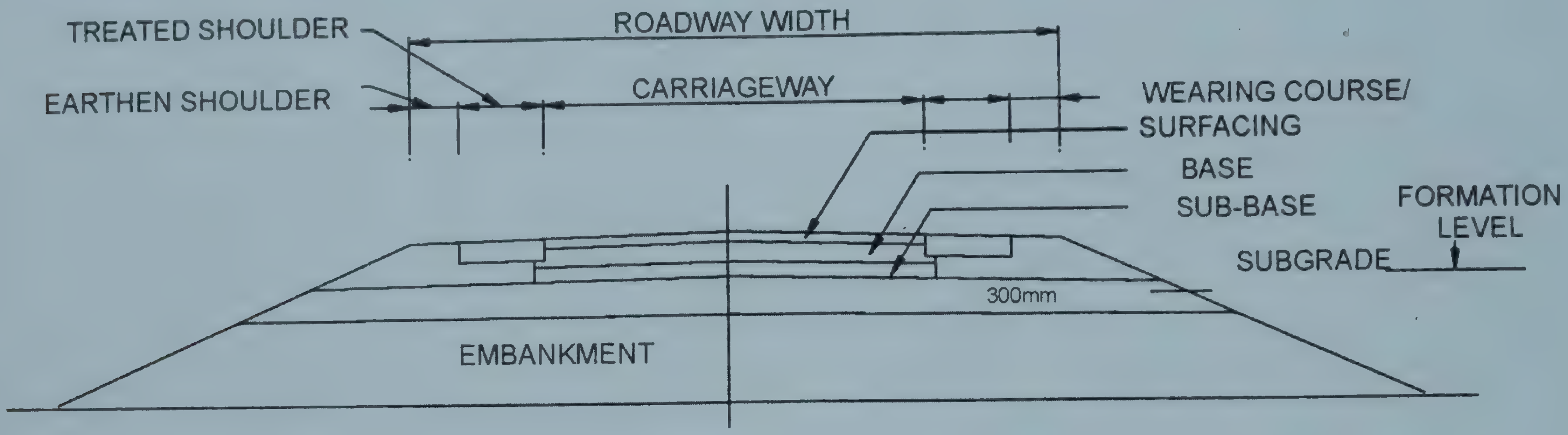

TREATED SHOULDER
ROADWAY WIDTH
EARTHEN SHOULDER
CARRIAGEWAY
WEARING COURSE/ SURFACING
BASE
SUB-BASE
FORMATION LEVEL
SUBGRADE
300mm
EMBANKMENT

Fig. 100.1 Terms Used in the Specifications to Describe Road Cross-Section Elements with a Flexible Pavement

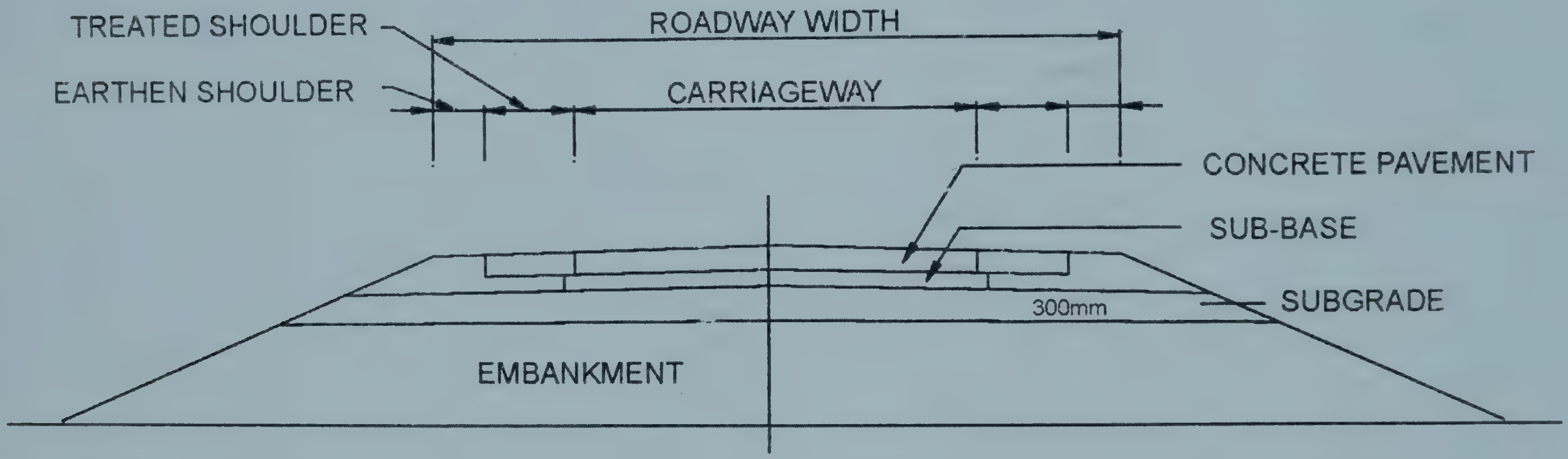

TREATED SHOULDER
ROADWAY WIDTH
EARTHEN SHOULDER
CARRIAGEWAY
CONCRETE PAVEMENT
SUB-BASE
SUBGRADE
300mm
EMBANKMENT

Fig. 100.2 Terms Used in the Specification to Describe Road Cross-Section Elements with a Cement Concrete Pavement

## 104 SCOPE OF WORK

**104.1** The work to be carried out under the contract, shall consist of the various items as described in the tender documents, the bill of quantities and the contract agreement.

**104.2** The works to be performed shall also include all general works preparatory to construction of roads, bridges, canal crossings, drainage and protection works, traffic arrangements during execution and all other related works. The works shall include work of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the intent and meaning of the drawings and these specifications and further drawings and orders that may be issued by the Engineer from time-to-time. The scope of work shall include compliance by the Contractor with all General Conditions of Contract, whether specifically mentioned or not in the various clauses of these specifications, all materials, apparatus, plant, equipment, tools, fuel, water, strutting, timbering, transport, offices, stores, workshop, staff, labour and provision of proper and sufficient protective works, diversions, temporary fencing, lighting for the safety of the public and protection of the works and adjoining land, first-aid equipment, sanitary accommodation of the staff and workmen, safety of workers, the effecting and maintenance of all insurances, the payment of all wages, salaries, fees, royalties, duties or other charges arising out of the execution of works and the regular clearance of rubbish, reinstatement and clearing up of the site as required on completion.

**104.3** The Contractor shall take all necessary actions to build in quality assurance in the planning, management and execution of works. The quality assurance shall cover all stages of work including setting out, selection of materials, construction method, equipment and plant, deployment of trained and experienced personnel, equipment operators and supervisory staff, quality control, site, environment, testing, etc.

**104.4** The QA-programme shall cover the quality assurances aspects of all services rendered, all items to be supplied and all construction and maintenance activities to be performed under the contract, also including temporary structures and equipment, which will influence the quality of the completed works or the progress of the contract.

As a minimum, it shall cover the following:

i) organization and management responsibility,

ii) document and data control,

iii) construction programme,

iv) methods statements,

v) process control,

vi) working, inspection, testing and documentation procedures,

vii) safety and emergency procedures,

viii) arrangements for traffic during construction and maintenance,

ix) control and documentation of purchasing and handling of materials,

x) non-conformity and corrective action,

xi) servicing,

xii) training of staff,

xiii) site environment plan.

The QA-programme shall be submitted to the Engineer for approval as specified in the Contract.

**104.5** The Contractor shall furnish at least 15 days in advance his programme for commencement of a particular item of work, the method of working, he intends to adopt for the relevant item, such as, construction for embankment, cutting, sub-base, base, surfacing, culverts, bridges, protection works, hill cutting, retaining wall, breast wall, side drains and such other items for which the Engineer demands the submission of the method of working. He shall provide information regarding the details of the method of working, and equipment he proposes to employ and satisfy the Engineer about the adequacy, appropriateness and safety of the same. The sole responsibility for the adequacy, appropriateness and safety of the methods adopted by the Contractor shall, however, rest on him, irrespective of any approval given by the Engineer. The Contractor shall submit a work schedule before the commencement of project for the approval of the Engineer.

**104.6** Any material not approved by the Engineer, shall be removed from the site forthwith.

**104.7** The work of building in quality assurance shall be deemed to be covered as incidental to the work.

## 105 CONSTRUCTION EQUIPMENT

In addition to the general conditions indicated in the contract, the following conditions regarding use of equipment in works shall be satisfied:

a) All equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to the Engineer.

b) All the plant and equipment to be deployed shall be appropriate to the work and shall be got approved from the Engineer. The Contractor may be required to give a trial run of the equipment before commencement of the work if directed by the Engineer.

c) No equipment or personnel shall be removed from site of work without prior approval of the Employer.

d) Any equipment not meeting the approval of the Engineer, shall be removed from the site forthwith.

## 106 CONTRACT DRAWINGS

**106.1** The drawings provided in the tender documents shall be used as a reference only. The Contractor shall visualize the nature and type of work contemplated and ensure that the rates and prices quoted by him in the bill of quantities take due consideration of the complexities of work involved during actual execution/construction.

**106.2** One copy of drawings on the basis of which actual execution of the work is to proceed, shall be furnished free of cost to the Contractor by the Engineer progressively according to the work programme submitted by the Contractor and accepted by the Engineer. Drawings for the particular activity shall be issued to the Contractor at least 21 days in advance of the scheduled date of the start of the activity.

**106.3** The tendered rates/prices for the work quoted by the Contractor in the BOQ shall be deemed to include the cost of preparation, supply and delivery of all necessary drawings, prints, tracings and negatives, which the Contractor is required to provide in accordance with the contract.

**106.4** Examination and/or approval by the Engineer, of any drawings or other documents submitted by the Contractor shall not relieve the Contractor of his responsibilities or liabilities under the contract.

## 107 SITE INFORMATION

**107.1** The information about the site of work and site conditions in the tender documents is given in good faith for guidance only but the Contractor shall satisfy himself regarding all aspects of site conditions.

**107.2** The location of the works and the general site particulars are as generally shown on the site plan/index plan enclosed with the tender documents.

**107.3** Whereas the right of way to the bridge sites/road works shall be provided to the Contractor, the Contractor shall have to make his own arrangements for the land required by him for field laboratory, site offices, labour camps, stores, etc.

**107.4** The Contractor is presumed to have, after a complete and careful examination, made an independent evaluation of the site, local conditions, physical qualities of ground, subsoil and geology and the nature and extent of difficulties, risks and hazards as are likely to arise. It is further assumed that the Contractor has inspected the quarries, borrow areas, etc. before quoting his rates for the work to assess the availability of construction materials in required quantity and quality. The Employer shall not be liable in any manner for any risks relating to the site, site conditions or the consequences thereof.

## 108 SETTING OUT

**108.1** The Contractor shall establish working bench marks, tied with the reference Bench mark in the area, soon after taking possession of the site. The Reference Bench mark for the area shall be as indicated in the contract documents and the value of the same shall be obtained by the Contractor from the Engineer. The working bench marks shall be at the rate of four per km and also at or near all drainage structures and bridges. The working bench marks/levels shall be got approved from the Engineer. Checks must be made on these benchmarks once every month and adjustments, if any, got agreed with the Engineer and recorded. An upto date record of all bench marks including approved adjustments, if any, shall be maintained by the Contractor and also a copy supplied to the Engineer for his record.

In the hilly areas, each and every reference pillar, made by the Department and handed over by the Engineer to the Contractor, shall work as a bench mark for hill cutting width as well as for level of hill cutting. It shall be the Contractor's responsibility to safeguard the reference pillars during construction. In case any pillar is damaged, the Contractor shall immediately inform the Engineer. The Contractor shall restore the pillar at his own cost as directed by the Engineer.

**108.2** The lines and levels of formation, side slopes, carriageway, shoulders and drainage and protection works shall be carefully set out and frequently checked, care being taken to ensure that correct gradients and cross-sections are obtained, everywhere.

**108.3** In order to facilitate the setting out of the works, the centre-line of the carriageway of road shall be accurately established by the Contractor and got approved from the Engineer. It must then be accurately referenced in a manner satisfactory to the Engineer, every 50 m intervals in plain and rolling terrain and 20 m intervals in hilly terrain with a closer spacing of 10 m on sharp curves, 5 m on hair pin bends or as directed by the Engineer, with marker pegs and chainage boards set in or near the fence line, and a schedule of reference dimensions shall be prepared and supplied by the Contractor to the Engineer. These markers shall be maintained until the works reach the finished formation level and are accepted by the Engineer.

**108.4** On construction reaching the formation level stage, the centre-line shall again be set out by the Contractor and, when approved by the Engineer, shall be accurately referenced in a manner acceptable to the Engineer, by marker pegs set at the outer limits of the formation.

No reference peg or marker shall be moved or withdrawn without the approval of the Engineer and no earthwork or structural work shall be commenced until the centre-line has been referenced.

**108.5** The Contractor shall be the sole responsible party for safeguarding all survey monuments, bench marks, reference pillars, beacons, etc. The Engineer will provide the Contractor with the data necessary for the setting out of the centre-line. All dimensions and levels shown on the drawings or mentioned in documents forming part of or issued under the contract, shall be verified by the Contractor on the site and he shall immediately inform the Engineer of any errors or discrepancies in such dimensions or levels. In connection with the staking out of the centre-line, the Contractor shall survey the terrain along the road and shall submit to the Engineer, for his approval, a profile along the road centre-line and cross-sections at intervals as required by the Engineer.

**108.6** After obtaining approval of the Engineer, work on earthwork can commence and the profile and cross-section shall form the basis for measurements and payment. The Contractor is responsible for checking that all the basic traverse points are in place at the commencement of the contract and if any are missing or appear to have been disturbed, the Contractor shall make arrangements to re-establish these points. A 'Survey File' containing the necessary data will be made available for this purpose. If, in the opinion of the Engineer, design modifications of the centre-line or grade are advisable, the Engineer will issue detailed instructions to the Contractor and the Contractor shall perform the modifications in the field, as required and modify the ground levels on the cross-section accordingly as many times as required.

### 108.7 Measurement for Payment

The work of setting out services shall be provided as a separate payable item in the bill of quantities and shall be measured in linear metre or in items of unit specified in the BOQ.

### 108.8 Rate

The Contract unit rate for the item of setting out services shall be payment in full for carrying out the required operations and services including full compensation for all labour, materials, tools, equipment, construction and establishing bench marks, reference pillars and their safeguarding, and all incidentals necessary to complete the work.

## 109 PUBLIC UTILITIES

**109.1** Drawings scheduling the affected services like water pipes, sewers, electric lines, cables etc., owned by the various authorities, public or private including local bodies indicated in the contract documents shall be verified by the Contractor for the accuracy of the information prior to the commencement of any work.

The Contractor's programme must take into account the period of notice and duration of diversionary works of each body and allow for any effect of these services and alterations upon the works and for arranging regular meetings with the various bodies at the commencement of the contract and throughout the period of the works in order to maintain the required coordination.

**109.2** No clearance or alterations to the utility shall be carried out unless specially ordered by the Engineer.

**109.3** Any services affected by the works shall be temporarily supported by the Contractor who shall also take all measures reasonably required by the various bodies to protect their services and property during the progress of the works.

**109.4** The Contractor may be required to carry out certain works for and on behalf of the various bodies and he shall also provide, with the prior approval of the Engineer, such assistance to the various bodies as may be authorised by the Engineer.

**109.5** The work of temporarily supporting and protecting the public utility services during execution of the works shall be deemed to be part of the contract and no extra payment shall be made for the same.

**109.6** The Contractor may be required to carry out the removal or shifting of certain services/utilities on specific orders from the Engineer, for which payment shall be made to him. Such works shall be taken up by the Contractor only after obtaining prior approval from the Engineer and ensuring adequate safety measures.

## 110 PRECAUTIONS FOR SAFEGUARDING THE ENVIRONMENT

The Contractor shall take all precautions for safeguarding the environment during the course of the construction of the works. He shall comply with the requirements of Section 2100 of these specifications.

## 111 ARRANGEMENTS FOR TRAFFIC DURING CONSTRUCTION

### 111.1 General

The Contractor shall at all times carry out work on the road in a manner creating least interference to the flow of traffic while consistent with the satisfactory execution of the same. For all works involving improvements to the existing road, the Contractor shall, in accordance with the directives of the Engineer, provide and maintain, during execution of the work, a passage for traffic either along a part of the existing carriageway under improvement, or along a temporary diversion constructed close to the road. Such temporary road or drainage works shall be safe for passage of normal traffic. The location of such stretches, alignment and longitudinal section of diversion and temporary drainage provision, if any, shall be as approved by the Engineer.

### 111.2 Traffic Management and Safety Plan

The objective shall be to provide for the proper management of the construction site so that all road users, i.e. pedestrians, cyclists, motor cyclists, animals and animal drawn carts and vehicular traffic are properly and safely accommodated. Before taking up any construction or maintenance operation/work, the Contractor shall prepare a Traffic Management and Safety Plan for each work zone and submit it to the Engineer for his prior approval. This plan should include inter alia.

i) Provision of traffic safety devices as per IRC:SP:55 with the following specifications

  a) Signages of retro-reflective sheet of high intensity grade.

  b) Delineators in the form of cones/drums (300 to 500 mm dia and 1000 mm high) made of plastic/rubber having retro-reflective red and white band, at a spacing of 5 m along with a reflective tape (red and white band) to be tied in between the gaps of cones/ drums. A bulb using solar energy or other source of light is to be placed on the top of the cone/drum for delineation in dark hours and night.

  c) Portable barricades painted with retro-reflective paint in alternate yellow and white stripes.

  d) Pavement markings

  e) Construction zone signs covering advance warning zone, approach transition zone, work zone, terminal transition zone.

  f) Other regulatory, warning and information signs

        g) Red lanterns or warning lights
        h) Provision of flagmen
    ii) Safety measures for workers engaged including personal protection equipment
    iii) First Aid arrangements
    iv) Details and drawings of arrangements in compliance with other sub clauses of this clause.

The Contractor shall ensure that all the traffic management devices as per Traffic Management and Safety Plan approved by the Engineer are in position before opening of sites of work.

If the Traffic Management and Safety Plan earlier approved by the Engineer, at any time during implementation is considered in the Engineer's opinion, to be insufficient or requiring revision to ensure safety of workers and users, the Engineer may instruct the Contractor to revise the Traffic Management and Safety Plan. The Contractor shall within seven days submit the revised plan to the Engineer for approval.

### 111.3 Traffic Safety and Control

The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as per the Traffic Management and Safety Plan submitted by the Contractor and approved by the Engineer, referred to in Sub-Clause 111.2. Before taking up any construction, arrangements for the diversion of traffic on the road shall be made in consultation with the Engineer.

The barricades erected on either side of the carriageway shall be of design to resist violation, and painted with alternate black and white stripes. Red lanterns or warning lights of similar type shall be mounted on the barricades at night and kept lit throughout from sunset to sunrise.

At the points where traffic is to deviate from its normal path (whether on temporary diversion or part width of the carriageway), the channel for traffic shall be clearly marked with the aid of pavement markings, painted drums or a similar device as per the directions of the Engineer. At night, the passage shall be delineated with lanterns or other suitable light source.

One-way traffic operation shall be established whenever the traffic is to be passed over part of the carriageway inadequate for two-way traffic. This shall be done with the help of temporary traffic signals or flagmen kept positioned on opposite sides during all hours. For regulation of traffic, the flagmen shall be equipped with red and green flags and lanterns/lights.

On both sides, suitable regulatory/warning signs, as approved by the Engineer, shall be installed for the compliance/guidance of road users. On each approach, at least two signs shall be put-up, one close to the point where transition of carriageway begins and the other 100 m away. The signs shall be of approved design and of reflectory type, as directed by the Engineer.

### 111.4 Maintenance of Diversions and Traffic Control Devices

All the signs, delineators, pavement markings, lights, barricades and other traffic control devices, as well as the riding surface of diversions shall be maintained in a satisfactory condition till such time they are required and as directed by the Engineer. The temporary travelled way shall be kept free of dust by frequent applications of water.

### 111.5 Measurements for Payment and Rate

i) All arrangements for traffic during construction as per the approved Traffic Management and Safety Plan including provision of all signages, pavement markings, barricades, other traffic control devices, flagmen, treated shoulders including their maintenance, dismantling and clearing debris, where necessary, shall be considered as incidental to the works and shall be the Contractor's responsibility. Non-Compliance shall be treated as per contract conditions.

ii) The construction of temporary diversion for bridges of 15 m length or more including temporary cross-drainage structures, as approved by the Engineer, shall be payable and measured in linear metre and the unit contract rate shall be inclusive of full compensation for construction (including supply of material, labour, tools, etc.) maintenance, final dismantling, and disposal.

## 112 GENERAL RULES FOR THE MEASUREMENT OF WORKS FOR PAYMENTS

### 112.1 General

All measurements shall be made in metric system. Different items of work shall be measured in accordance with the procedures set forth in the relevant Sections, read in conjunction with the general conditions of contract.

All measurements and computations, unless otherwise indicated, shall be carried nearest to the following limits:

| | | |
|---|---|---|
| 1) | Length and width | 10 mm |
| 2) | Height, depth or thickness of earthwork, subgrade, sub-bases, bases, surfacing and structural members | 5 mm |
| 3) | Areas | 0.01 sqm |
| 4) | Cubic content | 0.01 cum |

In recording dimensions of work, the sequence of length, width and height or depth or thickness shall be followed.

### 112.2 Measurements of Lead for Materials

Where lead is specified in the contract for construction materials, the same shall be measured as described hereunder.

Lead shall be measured over the shortest practical route and not the one actually taken and the decision of the Engineer in this regard shall be taken as final. Distances upto and including 100 m shall be measured in units of 50 m, exceeding 100 m but not exceeding 1 km in units of 100 m and exceeding 1 km in units of 500 m, the half and greater than half of the units shall be reckoned as one and less than half of the units ignored. In this regard, the source of the material shall be divided into suitable blocks and for each block, the distance from the centre of the block to the centre of placing pertaining to that block shall be taken as the lead distance.

### 112.3 Measurement of Pavement Thickness for Payment on Volume Basis

The finished thickness of sub-base, base, and bituminous course to be paid on volume basis shall be computed in the following manner:

Levels shall be taken before and after construction, at grid point of 10 m centre-to-centre longitudinally in straight reaches and 5 m at curves. Normally, on the two-lane roads, the levels shall be taken at four positions transversely, at 0.75 m and 2.75 m from either edge of the carriageway; and on single-lane roads these shall be taken at two positions transversely, being at 1.25 m from either edge of the carriageway.

Suitable reference for the transverse grid lines shall be left in the form of embedded bricks on either ends or by other means, so that it is possible to locate the grid points for level measurements after each successive course is laid.

For pavement courses laid only over widening portions, at least one line of levels shall be taken on each strip of widening, or more depending on the width of widening, as decided by the Engineer.

Notwithstanding the above, the measurements may be taken at closer intervals also if so directed by the Engineer, the need for which may arise particularly in the case of estimation of the volume of the material for profile corrective course (levelling course).

The average thickness of the pavement course in any area shall be the arithmetical mean of the difference of levels before and after construction of all the grid points falling in that area, provided that the thickness of finished work shall be limited to those shown on the drawings or approved by the Engineer in writing.

As supplement to level measurements, the Engineer shall have the option to take cores/ make holes to check the depth of construction.

### 112.4 Checking of Pavement Thickness for Payment on Area Basis

Where payment for any bituminous course as per Section 500 is allowed to be made on area basis, the Engineer may have its thickness checked with the help of a suitable penetration gauge at regular intervals or other means as he may decide.

## 113 SCOPE OF RATES FOR DIFFERENT ITEMS OF WORK

**113.1** For item rate contracts, the contract unit rates for different items of work shall be payable in full for completing the work to the requirements of the Specifications including full compensation for all the operations detailed in the relevant Sections of these Specifications under "Rates". In the absence of any directions to the contrary, the rates are to be considered as the full inclusive rates for finished work covering all labour, materials, wastage, temporary work, plant, equipment, overhead charges and profit and all items incidental to work, as well as the general liabilities, obligations, insurance and risks arising out of General Conditions of Contract.

**113.2** The item rates quoted by the Contractor shall, unless otherwise specified, also include compliance with/supply of the following:

i) General works, such as, clearance of site before setting out and clearance of works after completion;

ii) A detailed programme for the construction and completion of the work;

iii) Samples of various materials proposed to be used on the Work for conducting tests thereon as required as per the provisions of the Contract;

iv) Design of mixes as per the relevant Clauses of the Specifications giving proportions of ingredients, sources of aggregates and binder along with accompanying trial mixes as per the relevant Clauses of these Specifications to be submitted to the Engineer for his approval before use on the works; for concrete works nominal mixes producing desired strength could be used for CD Works. Design mixes are provided for pavement works;

v) Detailed design calculations and drawings for all Temporary Works (such as, formwork, staging, centering; specialized constructional handling and launching equipment and the like);

vi) Testing of various finished items and materials including bitumen, cement, concrete, bearings as required under these Specifications and furnishing test reports/certificates;

vii) All temporary works, formwork and false work;

viii) Establishing and running a laboratory as described in Clause 119 and with facilities for testing for various items of works as specified in Section 1800 and other relevant Clauses;

ix) Cost of in-built provision for Quality Assurance;

x) Cost of safeguarding the environment; and

xi) Arrangements for traffic at construction site and safety, health of workers.

## 114 METHODOLOGY AND SEQUENCE OF WORK

Prior to start of the construction activities at site, the Contractor shall, within a period as per Contract Agreement after the date of the Letter of Acceptance, submit to the Engineer for approval, the detailed construction methodology including mechanical equipment proposed to be used, sequence of various activities and schedule from start to end of the project. Programme relating to pavement and shoulder construction shall be an integrated activity to be done simultaneously in a coordinated manner. The methodology and the sequence shall be so planned as to provide proper safety, drainage and flow of traffic.

## 115 APPROVAL OF MATERIALS

Approval of all sources of material for work shall be obtained in writing from the Engineer before their use on the project.

## 116 SUPPLY OF QUARRY SAMPLES

Raw and processed samples of the mineral aggregates from the approved quarry shall be submitted by the Contractor at his own cost.

## 117 USE OF SURFACES BY CONSTRUCTION TRAFFIC

Ordinarily, no construction traffic shall be allowed on pavement under construction unless authorised by the Engineer. Even in that case, the load and intensity of construction traffic should be so regulated that no damage is caused to the sub-grade or pavement layers already constructed. Where necessary, temporary diversions shall be constructed for this purpose and the same shall be considered as incidental to the work.

## 118 SUPPLY OF COLOUR RECORD PHOTOGRAPHS AND ALBUMS

### 118.1 Scope

The work covers the supply of photographs, albums and compact discs to serve as a permanent record of various stages/facets of the work needed for an authentic documentation as approved by the Engineer.

### 118.2 Description

The Contractor shall arrange to take colour photographs at various stages/facets of the work including interesting and novel features of the work as directed by the Engineer. The photographs shall be taken with a digital camera with IST and GPS tagging and shall be of acceptable quality. The Contractor shall supply two colour prints of each of the photographs taken to the standard postcard size mounted in albums of quality acceptable to the Engineer. Each photograph in the album shall be suitably captioned. Also one compact disc shall be supplied of all the photographs taken with the Digital Camera.

### 118.3 Photographs are Property of the Employer

The photographs shall form part of the records of the Employer and the prints of the same shall not be supplied to anybody else nor published without the written permission of the Employer.

### 118.4 Measurements for Payment

Supply of two sets of colour record photographs mounted in the albums and the compact disc thereof shall be measured in number of record photographs supplied.

### 118.5 Rate

The rate for the supply of record photographs shall include the cost of taking the photographs, developing and obtaining colour prints, cost of album, mounting of photographs and captioning the same and cost of compact disc, etc.

## 119 FIELD LABORATORY

### 119.1 Scope

The work covers the provision and maintenance of an adequately equipped field laboratory as required for quality control of materials and workmanship; and trained manpower and essential documentation regarding sampling and test procedures.

### 119.2 Description

The Contractor shall provide and maintain adequately equipped field laboratory constructed as shown in drawings. The field laboratory shall preferably be located adjacent to the site office of the Engineer and provided with amenities like water supply, electric supply, and proper access. Routine tests for Quality Control which are required to be conducted on a day-to-day basis shall be conducted by the Contractor's Field Laboratory staff. The Contractor shall also provide one set of First Aid Box in the Laboratory.

### 119.3 Laboratory Equipment

**119.3.1** The following items of laboratory equipment shall be provided in the field laboratory.

a) For Earthwork, Granular Construction and other General Requirements:

| | | |
|---|---|---|
| i) | Post Hole Auger with extension | One set |
| ii) | Digging tools like pick axe, shovel, hammer, chisel, etc. | One set |
| iii) | IS Sieves with lid and pan<br>(125 mm, 100 mm, 90 mm, 80 mm, 75 mm, 63 mm, 53 mm, 50 mm, 45 mm, 37.5 mm, 31.5 mm, 26.5 mm, 22.4 mm, 20 mm, 19 mm, 16 mm, 13.2 mm, 12.5 mm 11.2 mm, 10 mm, 9.5 mm, 6.3 mm, 5.6 mm, 4.75 mm, 3.35 mm, 2.36 mm, 2 mm, 1.18 mm, 600 micron, 425 micron, 300 micron, 180 micron, 150 micron, 90 micron and 75 micron) | One set |

| | | |
|---|---|---|
| iv) | Standard Proctor Density Test Apparatus with Rammer | One set |
| v) | Sand Pouring Cylinder with tray complete for field density test | One set |
| vi) | Core Cutter (100 mm dia.), 100 mm/150 mm height complete with dolly and hammer | One set |
| vii) | Speedy moisture meter complete with chemicals | One set |
| viii) | Straight Edges | Two nos. |
| ix) | Liquid Limit and Plastic Limit testing apparatus complete with Water bottle and glass wares | One set |
| x) | Gas burner, sand bath | One set |
| xi) | Camber Board | Two nos. |
| xii) | Electronic/digital balance 1 kg with the least count of 0.01 gm | One no. |
| xiii) | Electronic/digital balance 5 kg | One no. |
| xiv) | Pan balance with weight Box, 5 kg | One no. |
| xv) | Oven (ambient to 200°C), thermostatically controlled | One no. |
| xvi) | Enamelled tray | Six nos. |
| xvii) | Measuring tape, spatula, spirit levels, glassware, porcelain dish, pestle mortar | One set |
| xviii) | Aggregate Impact Test Apparatus | One set |
| xix) | Flakiness gauge | Six nos. |
| xx) | Essential survey equipment for checking surface levels | One set |
| xxi) | Lab CBR equipment | One set |
| xxii) | Uppal's syringe for Plasticity Index | One set |
| xxiii) | Pocket Penetrometer | One set |

b) For Bituminous Construction

| | | |
|---|---|---|
| i) | Digital Thermometers | Three nos. |
| ii) | Water bath (ambient to 100°C) | One no. |
| iii) | Penetration apparatus (Bitumen) | One no. |
| iv) | Trays for measurement of tack coat quantity | Three nos. |
| v) | Bitumen extraction apparatus | One no. |

vi) Any other equipment specific to the quality control requirements of the work

c) For Cement Concrete Works and Structures

| | | |
|---|---|---|
| i) | Slump cone | Two nos. |
| ii) | Cube moulds (150 mm x 150 mm) | Twelve nos. |
| iii) | Core cutting machine | One no. |

**119.3.2** The Engineer shall have the right to waive the requirement of any equipment indicated in Sub-Clause 119.3.1 provided it is not considered relevant to the specifications for the works. Further, he shall have the right to direct the Contractor to provide any additional equipment not indicated in Sub-Clause 119.3.1 but considered relevant to the specification for the work and/or in accordance with the Quality Assurance Handbook for Rural Roads issued by the NRRDA, May 2007.

**119.3.3** Facilities at the District Laboratory and Central Laboratory or any other source would be utilized for conducting tests that cannot be covered by the Field Laboratory. The expenses for conducting such tests shall be payable by the Contractor, unless specifically exempt under the contract.

**119.3.4** The cost of setting up laboratory including first aid box, services, essential supplies, like, water, electricity, sanitary services and their maintenance and cost of all equipment, tools, materials, labour and incidentals to perform tests and other operation of quality control according to the Specification requirements shall be deemed to be incidental to the works and no extra payment shall be made for the same to the Contractor.

# 200

# SITE CLEARANCE

# 201 CLEARING AND GRUBBING

## 201.1 Scope

The work shall consist of cutting, trimming, removing and disposing of all materials such as trees, tree branches, bushes, shrubs, stumps, roots, grass, weeds, anthills, top organic soil not exceeding 150 mm in thickness, rubbish, loose stones, boulders, etc. which are undesirable and unsuitable for use in the works, from the designated area of road land, embankment slopes, drains, cross-drainage structures and such other areas as specified on the drawings or from areas as directed by the Engineer. It shall include grubbing, necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, removal and disposal of cleared materials in accordance with the requirements of these Specifications.

Clearing and grubbing shall be performed less than one month in advance of earthwork operations. Reclearing of the site of any vegetation, grass shrubs before commencement of work shall be carried out as directed by the Engineer and shall be incidental to the work of clearing and grubbing.

## 201.2 Preservation of Property/Amenities

Roadside trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all road facilities within or adjacent to the road which are not to be disturbed shall be protected from injury or damage by providing and installing suitable safeguards as shown in the drawing or as approved by the Engineer.

During clearing and grubbing, the Contractor shall take all adequate precautions for preservation of all vegetation adjacent to road land against soil erosion, water pollution, etc. and where required, shall undertake additional works to that effect. Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan including the procedure to be followed for disposal of waste materials, etc. and the schedule for carrying out additional work where required.

## 201.3 Conservation of Top–soil

The top-soil removed during clearing and grubbing of site, if suitable for re-use shall be transported, conserved and stacked as directed by the Engineer. This shall be incidental to the work.

## 201.4 Methods, Tools and Equipment

Only such methods, tools and equipment as are approved by the Engineer shall be adopted for the work. If the area has thick vegetation/roots/trees, a tractor-dozer may be required for clearance purposes. All trees, stumps, etc. falling within excavation and fill lines shall be cut to at least 500 mm depth below ground level and in no case shall these fall within 500 mm of the bottom of the subgrade. Also, all vegetation such as roots, under-growth, grass and other deleterious matter unsuitable for incorporation in the embankment/subgrade shall be removed between fill lines to the satisfaction of the Engineer. Beyond these clearing limits, trees and stumps which are required to be removed shall be cut down to 500 mm below ground level.

All branches of trees extending above the roadway shall be cut or trimmed so as to provide a clear height of 5 m above the road surface and shoulders.

All excavations below the general ground level arising out of the removal of trees, stumps etc. shall be filled with approved material and compacted to the required density, as directed by the Engineer.

### 201.5 Removal of Ant-hills

Ant-hills both above and below the ground, as are liable to collapse and obstruct free subsoil water flow shall be removed by excavating to a suitable depth as directed by the Engineer. The excavated ant-hills material shall be carted away from the site. Cavities in the ground due to removal of ant-hills shall be filled with approved material and compacted to the required density, as directed by the Engineer.

### 201.6 Disposal of Materials

All suitable and useable materials including trees, stumps, etc. arising from clearing and grubbing operations shall be the property of the Government and shall be properly stacked by the Contractor as here-in-after provided or as directed by the Engineer.

Trunks, branches and stumps of trees shall be cleaned of limbs and roots and stacked. Also boulders, stones and other materials usable in road construction shall be neatly stacked as directed by the Engineer. All materials shall be stacked at specified locations with all lifts and up to a lead of 1000 m.

Unsuitable and waste materials shall be cleared away from the site as directed by the Engineer and disposed of upto 1 km lead in accordance with State regulations.

### 201.7 Measurements for Payment

Clearing and grubbing for road embankment, drains and cross-drainage structures shall be measured on area basis in terms of hectares. Clearing and grubbing of borrow areas shall be incidental to embankment construction and the rates quoted for the embankment construction shall be inclusive of it.

Cutting of trees upto 300 mm in girth and removal of their stumps and roots, including removal of stumps and roots of trees upto 300 mm girth left over after trees have been cut by any other agency/government department, cutting/trimming of branches of trees extending above the roadway, and backfilling with approved material to the required compaction shall be considered incidental to the clearing and grubbing operations.

Cutting of trees above 300 mm in girth and removal of their stumps and roots including backfilling with approved material to the required compaction shall be measured in terms of number according to the sizes given below:

i) Above 300 mm to 600 mm
ii) Above 600 mm to 900 mm
iii) Above 900 mm to 1800 mm
iv) Above 1800 mm to 2700 mm
v) Above 2700 mm

Removal of stumps and roots of trees above 300 mm girth left over after trees have been cut by any other agency/government department, and backfilling with approved material to the required compaction shall be measured separately in terms of number according to the sizes (i) to (v) given above.

For the purpose of cutting of trees and removal of stumps and roots, the girth shall be measured at a height of 1 m above ground or at the top of the stump if the height of the stump is less than 1 m from the ground.

### 201.8 Acceptance

Acceptance of clearing and grubbing shall be based on visual inspection of the work for compliance with the above specifications to the satisfaction of the Engineer.

### 201.9 Rate

**201.9.1** The Contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. The rates shall also include cutting of trees upto 300 mm in girth and removal of their stumps and roots as well as removal of stumps upto 300 mm in girth left over after trees have been cut by any other agency/government department, excavation and backfilling with approved material to the required compaction, and handling, salvaging, stacking, and disposing of the cleared materials with all lifts and upto a lead of 1000 m.

**201.9.2** The Contract unit rate for cutting of trees of girth above 300 mm including removal of their stumps and roots shall include cutting, removal, excavation and backfilling with approved material to required compaction, handling, salvaging, stacking and disposing of the cleared materials with all lifts and upto a lead of 1000 m.

**201.9.3** The Contract unit rate for removal of stumps and roots of trees of girth above 300 mm left over after trees have been cut by any other agency/government department shall include removal, excavation and backfilling with approved material to the required compaction, handling, salvaging, stacking, and disposing of the cleared materials with all lifts and upto a lead of 1000 m.

**201.9.4** Where a Contract does not include separate items of clearing and grubbing, the same shall be considered incidental to the earthwork items and the Contract unit prices for the earthwork shall be considered as including clearing and grubbing operations.

## 202 DISMANTLING CULVERTS, SMALL BRIDGES, PAVEMENTS AND OTHER STRUCTURES

### 202.1 Scope

This work shall consist of dismantling and removing existing culverts, bridges, pavement, kerbs, and other structures like railings, parapets, fences, utility services, manholes, catch basins, inlets etc., which interfere with the new construction or are not suitable to remain in place, including salvaging and disposing of the surplus/unsuitable materials and backfilling the resulting trenches and pits with suitable material to the required compaction as directed by the Engineer.

Existing culverts, bridges, pavement and other structures which are within the road land and which are designated for removal, shall be removed upto the limits and extent specified in the drawings or as directed by the Engineer.

Dismantling and removal operations shall be carried out using appropriate tools and equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place.

All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

### 202.2 Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the resulting materials so removed as to salvage serviceable materials and not to cause any damage to the part of the structure to be retained and any other properties or structures or utilities nearby.

Unless otherwise specified, the superstructure portion of culverts/bridges shall be entirely removed and other parts removed at least 600 mm below the bed level or as necessary depending upon the interference they cause to the new construction. Removal of overlying or adjacent material, if required in connection with the dismantling of the structures, shall be incidental to this item.

Where existing culverts/bridges are to be widened/strengthened or otherwise incorporated in the new work, only such part or parts of the existing structure shall be removed as are necessary to provide a proper connection to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grade without weakening or damaging any part of the structure to be retained. Due care should be taken to ensure that reinforcing bars which are to be left in place so as to project into the new work as dowels or ties are not damaged during removal of concrete and protected against rusting and corrosion.

Pipe culverts shall be carefully removed in such a manner as to avoid damage to the pipes.

Steel structures shall be carefully dismantled in such a manner as to avoid damage to members thereof. If the structure is to be removed in a condition suitable for re-erection as specified in the drawings or directed by the Engineer, all members shall be match- marked with white lead paint by the Contractor before dismantling. All loose parts like pins, nuts, loose plates, etc. shall be securely wired to adjacent members or packed in boxes with proper markings for the ease of identification at the time of re-erection of the structure.

Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber to be salvaged as is designated by the Engineer.

### 202.3 Dismantling Pavement and Other Structures

In removing pavements, kerbs, gutters, and other structures like railings, parapets, fences, manholes, catch basins, inlets, etc. where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with a face perpendicular to the surface of the existing structure. Sufficient removal shall be made to provide for proper grades and connections with the new work as directed by the Engineer.

Concrete pavements designated for removal shall be broken to pieces and stock piled at designated locations or disposed of as directed by the Engineer.

### 202.4 Backfilling

Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to the required density as directed by the Engineer.

### 202.5 Disposal of Materials

All useable materials, stones, pipes, steel, timber obtained by dismantling, shall be the property of Government and shall be neatly stacked at the designated locations as directed by the Engineer with all lifts and upto a lead of 1000 m.

Timber or lumber salvaged from old structures shall have all nails and bolts removed and then stacked.

All waste materials shall be disposed of as directed by the Engineer with all lifts and upto a lead of 1000 m.

### 202.6 Acceptance

Acceptance of dismantling and removal of salvaged material shall be based on visual inspection of the work and backfilling and compaction shall comply with the tests specified for such work in these Specifications.

### 202.7 Measurements for Payment

The work of dismantling shall be paid for in units indicated below by taking measurements before and after, as applicable:

| | | |
|---|---|---|
| i) | Dismantling brick/stone masonry/concrete (Plain and reinforced) | cum |
| ii) | Dismantling flexible and cement concrete pavement | cum |
| iii) | Dismantling steel structures | tonne |
| iv) | Dismantling pipes, guard rails, kerbs, gutters and fencing | linear m |
| v) | Utility services (poles/others) | Nos./<br>linear m |

### 202.8 Rate

The Contract unit rates for the various items of dismantling shall be paid in full for carrying out the required operations including all labour, materials, tools, equipment, safeguards and incidentals necessary for the satisfactory completion of the work. These rates shall also include excavation and backfilling with suitable material to the required compaction and for handling, salvaging, stacking, and disposing of the dismantled materials within all lifts and upto a lead of 1000 m.

# 300

# EARTHWORKS

## 301 EMBANKMENT CONSTRUCTION

### 301.1 Scope

The work shall consist of construction of embankments and miscellaneous backfills with approved material obtained from roadway and drain excavation, borrow pits or other sources. All embankments and miscellaneous backfills shall be constructed in accordance with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 301.2 Definition of Earthwork Materials

### 301.2.1 *Topsoil*

Topsoil is a soil which, on visual examination, can be seen to be capable of supporting plant growth.

### 301.2.2 *Suitable fill material*

Materials conforming to the requirements specified in Clause 301.3 shall be considered suitable for embankments and backfills.

### 301.2.3 *Unsuitable fill material*

The following types of materials shall be considered unsuitable:

i) Materials from swamps, marshes and bogs,

ii) Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS:1498,

iii) Material susceptible to spontaneous combustion,

iv) Clays having Liquid Limit exceeding 70 and Plasticity Index exceeding 45,

v) Expansive clays with 'Free Swelling Index' exceeding 50 percent when tested as per IS:2720 Part 40,

vi) Materials in a frozen condition

vii) Materials with salts resulting in leaching in the embankment, such as salt-infested soils with pH>8.5 (sodic soils), when tested as per IS:2720 Part 26;

viii) Materials with a soluble sulphate content exceeding 1.9 gm of sulphate (expressed as $SO_3$) per litre, if deposited within 500 mm or other distance described in the Contract, of concrete, cement bound materials or other cementitious materials forming part of the permanent works.

ix) Materials with a total sulphate content (expressed as $SO_3$) exceeding 0.5 percent by mass, if deposited within 500 mm, or other distance described in the Contract, of metallic items forming part of the permanent works.

### 301.3 Physical Requirements of Embankment Materials

**301.3.1** The materials used in embankments and miscellaneous backfills shall be soil, moorum, gravel, fly-ash, slag, a mixture of these or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment. The materials considered unsuitable in accordance with Clause 301.2.3 shall not be used.

**301.3.2** The size of the coarse material in the mixture of soil shall ordinarily not exceed 75 mm when placed in the embankment. However, the Engineer may, at his discretion, permit the use of material coarser than this also, if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these Specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

**301.3.3** Only the materials satisfying the density requirements given in **Table 300.1** shall be used. These requirements shall not apply to light weight fill materials like fly-ash, etc

**Table 300.1 Minimum Density Requirements for Suitability of Embankment Materials**

| S.No. | Type of Work | Maximum Laboratory Dry Unit Weight, Tested as per IS:2720 (Part 7) |
|---|---|---|
| 1) | Embankments not subject to flooding: | Not less than 14.4kN/$m^3$ |
| 2) | Embankments subject to flooding or exceeding 3 m height | Not less than 15.2kN/$m^3$ |

### 301.3.4 General Requirements

The materials for embankment shall be obtained from approved sources, suitable materials becoming available from nearby roadway excavation or any other excavation under the same Contract. The work shall be so planned and executed that the best available materials are used in the top portion of the embankment

#### *301.3.4.1 Borrow pits*

The Contractor shall be responsible for the arrangement for the source of supply of embankment material and shall comply with the environmental requirements as laid down by the Government and the local bodies, and these specifications. The Contractor shall carry out the required tests prior to construction in accordance with Section 1800 and submit to the Engineer for his approval.

Borrow pits along the road shall be discouraged. If permitted by the Engineer, these shall comply with the following requirements

a) **Location and Shape:** Borrow pits shall be rectangular in shape with one side parallel to the centreline of the road. If on road land, they shall be dug as near the road boundary as possible. In any case, no borrow pits shall be dug within a distance equal to the height of the embankment, subject to a minimum of 1.5 m, from the toe of the final section of the road embankment, after making due allowance for future development.

Borrow pits shall not be dug continuously. Ridges of not less than 8 m width shall be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage.

b) **Depth:** The depth of borrow pits shall be so regulated that :

   i) The bottom of the pits do not cut an imaginary line having a slope of 1 vertial to 4 horizontal projected from the edge of the final section of the road embankment; the maximum depth in any case being limited to 1 m.

   ii) The bed level of the pits shall slope down progressively towards the nearest cross drain, if any, and shall not be lower than the bed of the cross drain.

   iii) Where the pits are on temporarily arranged cultivable land, the depth shall not exceed 450 mm. The topsoil to a depth of 150 mm shall be stripped and stacked aside. Thereafter, soil may be dug to a further depth not exceeding 300 mm. The topsoil shall then be spread back on the land.

c) **Special Cases:**

   i) In areas of high water table, yielding suitable borrow material, the borrow pits shall take the form of deep narrow continuous ditches, connected with natural drainage, so as to conserve as much land as possible.

   ii) Borrow pits shall not be dug within 800 m of towns or villages. If unavoidable, they shall not exceed 300 mm in depth and shall be drained.

   iii) Where the road embankment is used as a flood bank, as far as possible, earth shall be borrowed only from the river side. The inner edge of any borrow pit shall not be less than 15 m from the toe of the bank. Where borrowing earth from the landside cannot be avoided, a berm at least 25 m wide shall be left between the borrow pit and the toe of the bank.

The toe of the bank on the rear side shall have a cover of 750 mm to 1.25 m over the saturation line drawn at a slope of 1 in 6 from the high flood level on the river side.

*301.3.4.2* The Contractor shall, at least 7 working days prior to commencement of compaction submit to the Engineer for approval:

i) Soil classification test data

ii) The values of maximum dry density and optimum moisture content obtained in accordance with IS:2720 (Part 7) for each of the fill materials proposed to be used, together with the dry density - moisture content relationship graph.

The maximum dry density and optimum moisture content approved by the Engineer shall form the basis for compaction.

The embankment shall be compacted in layers to the density requirements given in **Table 300.2**.

**Table 300.2 Compaction Requirements for Embankment**

| Type of Work/Material | Relative Compaction Percentage of Maximum Laboratory Dry Density Obtained by Standard Proctor Test as per IS:2720 (Part 7) |
|---|---|
| Embankment | Not less than 98% |
| Expansive Clays | 90% - 95% |

### 301.4 Fly-ash

Use of fly-ash shall be made in accordance with the guidelines of the Ministry of Environment and Forest. Where fly-ash is used, its physical and chemical properties and the embankment construction shall conform to the requirements of Clause 306. The term fly-ash shall cover coal ash such as pond ash, bottom ash or mound ash.

### 301.5 Construction Operations

### 301.5.1 *Setting out*

After the site has been cleared as per Section 200, the limits of embankment shall be marked by fixing batter pegs and marking the toe lines on both sides at regular intervals as per Section 100 before commencing the earthwork. The embankment shall be built sufficiently wider than the design dimension so that the surplus material at the edges (which does not receive the same degree of compaction as the rest of the embankment) may be trimmed ensuring that the remaining material is compacted to the desired density and in position specified and conforms to the specified side slopes.

### 301.5.2 *Dewatering*

If the foundation of the embankment is in an area with stagnant water, and in the opinion of the Engineer, it is feasible to remove it, the same shall be removed by bailing out or pumping, as directed by the Engineer, and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair/restore it to original condition or compensate the damage at his own cost.

### 301.5.3 *Stripping of topsoil*

The topsoil from all areas to be covered by embankment shall be stripped to a depth not exceeding 150 mm and stored in stockpiles of height not exceeding 2 m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired.

### 301.5.4 *Preparing foundation (ground supporting embankment)*

The ground shall be leveled, watered if necessary, and rolled to a well compacted surface for placement of the embankment. In case where the difference between the top of the subgrade and the ground level is less than 600 mm, the ground shall be loosened to a minimum depth of 150 mm and compacted in accordance with Clauses 301.5.5 and 301.5.6.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation shall be removed to the required depth and replaced with suitable soil and compacted as directed by the Engineer.

### 301.5.5 *Spreading and moisture control*

*301.5.5.1* Embankment material shall be spread in layers of uniform thickness over the entire width of embankment. The depth of each layer of filling shall suit the compaction plant and the compaction procedure approved by the Engineer. The thickness of layer shall be as specified in Clause 301.5.6.

Where materials of appreciably different characteristics are to be deposited in embankments, such materials shall be spread in separate layers, each layer composed of only one type of material.

*301.5.5.2* Layers shall be placed, at such cross-falls as will shed storm water and prevent ponding.

*301.5.5.3* Each layer shall be finished by a suitable tractor-towed appliance or manually, using camber board to achieve the specified slope and grade and compacted as per Clause 301.5.6. Successive layers shall not be placed until the layer under consideration has been thoroughly compacted to the specified requirements given in **Table 300.2** and got approved by the Engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

*301.5.5.4* Moisture content of the material shall be checked at the site of placement prior to commencement of compaction. The moisture content shall be within ± 2 percent of OMC. Clay soils shall be compacted on the wet side of the optimum. If the material is too dry, it shall be brought to the acceptable limit by adding the required amount of water uniformly by a trailer mounted water bowser and thoroughly mixing in the soil by blading, discing or harrowing until uniform moisture content is obtained through the depth of the layer. If the material delivered is too wet, it shall be dried by aeration or by blading, discing or harrowing until the moisture content is satisfactory for compaction. Clods of earth, if any, shall be broken to a maximum size of not more than 75 mm. The Contractor shall conserve the moisture content of material excavated when this is close to the optimum moisture content and such material shall not be stockpiled or double handled, as far as practicable, and shall be spread and compacted without delay. Allowance shall be made for evaporation, for instance in excessively hot weather, by the addition of extra moisture so that compaction is carried out at the specified moisture content.

### 301.5.6 *Compaction*

Only the compaction equipment approved by the Engineer shall be employed to compact the different types of materials encountered during construction. The compacted layer thickness shall not exceed 150 mm if static smooth-wheeled rollers of 80 to 100 kN static weight are used. For higher compacted layer thicknesses upto 200 mm, vibratory rollers of 80 to 100 kN static weight shall be used. The Contractor shall demonstrate the efficacy of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for these site trials shall first be submitted to the Engineer for approval. Rolling shall begin at the edge of the fill and progress towards the centre line, overlapping on successive trips by about one half the width of the roller unit. On superelevated curves, rolling shall begin at the lower edge and progress towards the higher edge.

Each layer of the material shall be thoroughly compacted to the densities specified in **Table 300.2**. The degree of compaction shall be measured in each layer, as laid down in Section 1800.

Subsequent layers shall be placed only after the finished layer has been tested and accepted by the Engineer.

When density measurements reveal any soft areas, further compaction shall be carried out as directed by the Engineer. If in spite of that, the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted to the density requirements to the satisfaction of the Engineer.

### 301.5.7 *Repairs of damages caused by rain/spillage of water*

When damages to embankment are caused by rain or otherwise, the soil in the affected portion shall be removed in such areas as directed by the Engineer before the next layer is laid and compacted. Tests shall be carried out as directed by the Engineer to ascertain the density requirements of the repaired area. The work of repairing the damages shall be carried out by the Contractor at his own cost including the arrangement of machinery/ equipment for the purpose.

### 301.5.8 *Embankment around structures*

To avoid interference with the construction of abutments, wing walls or return walls of culvert/bridge structures, the Contractor shall, at points to be determined by the Engineer, suspend work on embankment forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit the completion of approaches without the risk of damage to the structure.

Unless directed otherwise, the filling around culverts, bridges and other structures upto a distance of twice the height of the road from the back of the abutment shall be carried out independent of the work on the main embankment. The fill material shall not be placed against any abutment or wing wall, unless permission has been given by the Engineer but in any case not until the concrete or masonry has been in position for 14 days. The embankment and subgrade shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the Engineer.

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material.

Where it may be impracticable to use conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory roller, plate compactor or power rammer. Care shall be taken to see that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to them or excessive pressure against the structure.

### 301.6 Finishing Operations

Finishing operations shall include the work of shaping and dressing the shoulders/verge/ roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the drawings or as directed by the Engineer subject to the surface tolerance described in Section 1800. Both the upper and lower ends of the side slopes shall be rounded-off to improve appearance and to merge the embankment with the adjacent terrain.

The topsoil, removed and conserved earlier (Clause 301.5.3) shall be spread over the fill slopes as per directions of the Engineer to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil in order to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being 100 to 150 mm. Where directed, the slopes shall be turfed.

### 301.7 Earthwork for Widening Existing Road Embankment

When an existing embankment and/or subgrade is to be widened and its slopes are steeper than 1 vertical to 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment/subgrade material to be added. The material obtained from cutting of benches may be utilised in the widening of the embankment/subgrade. However, when the existing slope against which the fresh material is to be placed is flatter than 1 vertical to 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

When the width of the widened portions is insufficient to permit the use of conventional rollers, compaction shall be carried out with the help of small vibratory rollers/plate compactors/power rammers or any other appropriate equipment approved by the Engineer. End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other types of hauling equipment.

### 301.8 Earthwork Against Sloping Ground

Where an embankment/subgrade is to be placed against sloping ground, the latter shall be benched or ploughed/scarified as required in clause 301.5 before placing the embankment subgrade material. The work of benching, ploughing/scarifying and extra earthwork involved shall be considered incidental to the item of earthwork.

### 301.9 Earthwork over Existing Road Surface

Where the embankment is to be placed over an existing road surface, the work shall be carried out as indicated below:

i) If the existing road surface is of granular or bituminous type and lies within 1 m of the new formation level, the same shall be scarified to a depth of 50 mm or more as specified, so as to provide ample bond between the old and new material ensuring that the thickness of the soil layer, if any, interposed between the pavement and the scarified surface shall not be less than 300 mm and the soil and its compaction shall meet the requirements for the subgrde.

ii) If the existing road surface is of cement concrete type and lies within 1 m of the new formation level, the same shall be removed completely.

iii) If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be permitted to stay in place without any modification.

### 301.10 Embankment Construction Under Water

Where embankment filling is to be placed under water, only acceptable granular material shall be used unless otherwise approved by the Engineer. Acceptable granular material shall consist of hard durable material with maximum particle size not exceeding 75 mm. The material shall be non-plastic having uniformity coefficient of not less than 10. The material shall be deposited by end tipping without compaction.

### 301.11 Earthwork for High Embankment

The material for high embankments (more than 6 m) shall conform to the requirements specified in the design.

Where provided, stage construction and controlled rate of filling shall be carried out, and the embankment shall remain in place for the specified settlement period, if any, before excavating for abutments, wing walls, retaining walls, footings etc.

### 301.12 Plying of Traffic

Construction and other vehicular traffic shall not use the prepared surface of the embankment and/or subgrade without the prior permission of the Engineer. Any damage arising out of such use shall, however, be made good by the Contractor at his own cost as directed by the Engineer.

### 301.13 Surface Finish and Quality Control of Work

Control on the quality of materials and works shall be exercised in accordance with Section 1800 of these Specifications.

## 301.14 Measurements for Payment

The work of embankment construction shall be measured by taking cross-sections at intervals in the original position, after clearing and grubbing the site, and after completion of embankment. The volume of earthwork shall be computed in cubic metres by the method of average end areas.

The measurement of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought from roadway and drainage excavation. For this purpose, it shall be assumed that one cum of suitable material brought to site, from road and drainage excavation, forms one cum of compacted fill and all bulking or shrinkage shall be ignored.

Stripping of topsoil to the specified depth including storing and reapplication shall be measured in square metres.

Work involving loosening and recompacting of ground supporting embankment shall be measured in cubic metres.

Removal of unsuitable material at embankment foundation and replacement with suitable material shall be measured in cubic metres.

Embankment constructed with flyash shall be measured in cubic metre separately for (i) soil used for cover and intervening layers, and (ii) flyash

Construction of embankment under water shall be measured in cubic metres.

Construction of high embankment with specified material and in specified manner shall be measured in cubic metres.

Scarifying existing granular/bituminous road surface shall be measured in square metres.

Dismantling and removal of existing cement concrete pavement shall be measured as per Section 200.

Filter medium and backfill material behind abutments, wing walls and other retaining structures shall be measured as finished work in position in cubic metres.

Setting out shall be measured in linear metres (refer Section 100).

## 301.15 Rate

**301.15.1** The Contract unit rates for the items of embankment construction shall be payment in full for carrying out the required operations including full compensation for :

i) Cost of arrangement of land as a source of supply of material of required quantity for construction unless provided otherwise in the Contract;

ii) Compacting ground supporting embankment except where removal and replacement of suitable material or loosening and recompacting is involved;

iii) Scarifying or cutting continuous horizontal benches 300 mm wide on side slopes of existing embankment and subgrade as applicable;

iv) Cost of watering or drying of material in borrow areas and/or embankment during construction as required;

v) Spreading in layers, bringing to appropriate moisture content and compacting to Specification requirements;

vi) Shaping and dressing top and slopes of the embankment including rounding of corners;

vii) Restricted working at sites of structures;

viii) Working on narrow width of embankment;

ix) Excavation in all soils from borrow pits/designated borrow areas including clearing and grubbing and transporting the material to embankment site with all lifts and leads unless otherwise provided for in the Contract;

x) All labour, materials, tools, equipment and incidentals necessary to complete the work to the Specifications;

xi) Dewatering; and

xii) Keeping the embankment/completed formation free of water.

**301.15.2** In case the Contract unit rate specified is not inclusive of all leads, the unit rate for transporting material beyond the initial lead, as specified in the Contract for construction of embankment shall be inclusive of full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the specified initial lead.

**301.15.3** The Contract unit rate for the items of stripping and storing topsoil and of reapplication of topsoil shall include full compensation for all the necessary operations including all lifts, and upto a lead of 1000 m or as otherwise specified.

**301.15.4** The Contract unit rate for loosening and recompacting the loosened materials shall include full compensation for loosening to the specified depth, including breaking clods, spreading in layers, watering where necessary and compacting to the requirements.

**301.15.5** Clauses 302.9.1 and 301.14.1 shall apply as regards Contract unit rate for item of removal of unsuitable material and replacement with suitable material respectively.

**301.15.6** The Contract unit rate for scarifying existing granular/ bituminous road surface shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. This will also comprise of handling, salvaging, stacking and disposing of the dismantled materials within all lifts and upto a lead of 1000 m or as otherwise specified.

**301.15.7** The Contract unit rate for providing and laying material behind abutments shall be payment in full for carrying out the required operations including all materials, labour, tools, equipment and incidentals to complete the work to the Specifications.

**301.15.8** Clause 301.10 shall apply as regards contract unit rate for construction of embankment under water.

**301.15.9** Clause 301.11 shall apply as regards contract unit rate for construction of high embankment.

**301.15.10** Section 200 shall apply as regards contract unit rate for dismantling and disposal of existing cement concrete pavement.

**301.15.11** The cost of sampling, testing and quality control shall be borne by the Contractor.

## 302 EARTHWORK IN CUTTING

### 302.1 Scope

The work shall consist of excavation, removal and satisfactory disposal of all materials necessary for the construction of roadway, side drains and waterways in accordance with the requirements of these Specifications and the lines, grades and cross-sections shown in the drawings or as indicated by the Engineer. It shall include earthwork in excavation in all types of soils and rocks including hauling and stacking of material useful for construction at suitable sites and safe disposal of unsuitable cut materials in specified manner with all lifts and lead upto 1000 m, trimming, filling of uneven spots, and finishing of the surface to specified dimensions or as directed by the Engineer.

### 302.2 Classification of Excavated Material

### 302.2.1 *Classification*

All materials involved in excavation shall be classified as under :

a) Soil

b) Ordinary Rock (not requiring blasting)

c) Hard Rock (requiring blasting)

d) Hard Rock (blasting prohibited)

e) Marshy Soil

Further details pertaining to the above Classification are provided at **Annexure-300.1**.

**302.2.2** The classification of excavated material shall be decided by the Engineer and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification until blasting is clearly necessary in the opinion of the Engineer.

### 302.3 Construction Operations

**302.3.1** After site clearance as per Section 200, the limits of excavation shall be set out as per Section 100 to lines, curves, slopes, gradients and cross-sections as shown on the drawings or as per directions of the Engineer. This shall be achieved by constructing job pillars, level pillars, reference pillars, cross-section points, back-cutting lines (back of formation) and reference lines.

In case of hill roads, the actual area to be cleared shall be marked on ground with reference to the trace-cut. The trace-cut shall be about one metre wide track, cut along the selected alignment to facilitate access to the area for inspection and survey. It may not be possible to cut a trace where the pegged route traverses through unapproachable area and may, therefore, be detoured at such locations by cutting the trace either along the top or bottom periphery of these areas. Reference line (hill side edge) shall be marked on ground at 1.5 m above the edge of proposed back-cutting line of formation width and valley side reference line shall be marked at 1.5 m below the trace cut (formation) level.

### **302.3.2** *Stripping and storing topsoil*

When so directed by the Engineer, the topsoil (defined as per Clause 301.2.1) existing over the sites of excavation shall be stripped to specified depths and stockpiled at designated locations for re-use in covering embankment slopes, cut slopes, berms and other disturbed areas where re-vegetation is desired in accordance with Clause 301.5.4. Prior to stripping the topsoil, all trees, shrubs, etc. shall be removed along with their roots, with approval of the Engineer.

### **302.3.3** *Excavation – General*

All excavations shall be carried out in conformity with the directions as given below and in a manner approved by the Engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilised as approved by the Engineer. While planning or executing excavations, the Contractor shall take all adequate precautions against soil erosion and water pollution, etc. and take appropriate drainage measures to keep the site free of water.

The excavation shall be done manually or mechanically using excavator, or tractor fitted with excavation arrangement depending on the job requirement. Two-stage construction, i.e., first making 2.5 m track and then widening, shall be done if light vehicle communication is to be established as an urgent requirement. In other cases, single stage construction shall be done.

The excavations shall conform to the lines, grades, side slopes and levels shown on the drawings or as directed by the Engineer. The Contractor shall not excavate outside the limits of excavation. Subject to the permitted tolerances, any excess depth/width excavated beyond the specified levels/dimensions on the drawings shall be made good at the cost of the Contractor with suitable material of characteristics similar to that removed and compacted to the requirements of Clause 301.

All debris and loose material on the slopes of cuttings shall be removed. No backfilling shall be allowed to obtain required slopes excepting that when, boulders or soft materials are encountered in cut slopes, these shall be excavated to approved depth on instructions of the Engineer and the resulting cavities filled with suitable material and thoroughly compacted in an approved manner.

After excavation, the sides of excavated area shall be trimmed and the area contoured to minimise erosion and ponding, allowing for natural drainage to take place. Compensatory afforestation cost for damage to trees shall be paid to the Forest Department as per relevant Act.

### 302.3.3.1 *Damage to property caused by excavation and safe disposal of debris*

The excavated debris shall be saved from falling on the side slopes down below the formation to avoid damage to private or Govt. property and damage and erosion of hill slopes and damage of trees. Checkwalls shall be made by the Contractor for this purpose at his own cost. The Contractor shall restore at his own cost any damage caused by his negligence.

All excavated material shall be disposed of to designated places with all llifts and lead up to 1000 m as directed by the Engineer. Stacking of debris etc. along any roadside shall not be permitted.

### 302.3.3.2 *Construction of cross-drainage works and side drains*

In the case of hill roads,cross-drainage works like scuppers, small culverts and side drains, shall be included in the formation cutting contract and construction shall be carried out causing least interference to natural drainage.

### **302.3.4** *Methods, tools and equipment*

Only such methods, tools and equipment as approved by the Engineer shall be adopted/ used in the work. If so directed by the Engineer, the Contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of work.

### **302.3.5** *Rock excavation*

Rock, when encountered in road excavation, shall be removed upto the formation level or as otherwise indicated on the drawings. Where, however, unstable shale or other unsuitable materials are encountered at the formation level, these shall be excavated to the extent of 500 mm below the formation level or as otherwise specified. In all cases, the excavation operations shall be so carried out that at no point on cut formation, the rock protrudes above the specified levels. Rocks and large boulders which are likely to cause differential settlement and also local drainage problems should be removed to the extent of 500 mm below the formation level in full formation width including side drains.

Where excavation is done to levels lower than those specified, the excess excavation shall be made good to the satisfaction of the Engineer.

All loose pieces of rock on excavated slope surface which move when pierced by a crowbar shall be removed and slopes shall be finished to uniform lines corresponding to slope lines shown on the drawings or as directed by the Engineer.

Where blasting is to be resorted to, the same shall be carried out to Clause 304 and all precautions indicated therein observed.

Where presplitting is prescribed to be done for the establishment of a specified slope in rock excavation, the same shall be carried out to Clause 304.

### 302.3.6 *Excavation in marshy soil*

The excavation of soils from marshes/ swamps shall be carried out as per the programme approved by the Engineer.

Excavation of marshes shall begin at one end and proceed in one direction across the entire marsh immediately ahead of backfilling. The method and sequence of excavating and backfilling shall be such as to ensure, to the extent practicable, the complete removal or displacement of all muck from within the lateral limits indicated on the drawings or as staked by the Engineer, and to the bottom of the marsh/firm support or levels as indicated on the Drawings.

### 302.3.7 *Excavation of road shoulders for widening of pavement or providing treated shoulders*

In works involving widening of existing pavements or providing treated shoulders, the existing shoulders shall be removed to their full width and to levels shown on drawings or as indicated by the Engineer. The subgrade material within 300 mm thickness, or as directed, in the portion excavated for widening or providing treated shoulders shall be loosened and recompacted to 100 percent Proctor density as per Clause 303. While doing so, care shall be taken to see that no portion of the existing pavement designated for retention is loosened or disturbed. If the existing pavement gets disturbed or loosened, it shall be dismantled and cut to a regular shape with sides vertical and the disturbed/loosened portion removed completely and relaid as directed by the Engineer, at the cost of the Contractor.

### 302.3.8 *Excavation for surface drains*

Where the Contract provides for construction of surface/sub-surface drains to Clause 307, excavation for these shall be carried out in proper sequence with other works as approved by the Engineer.

### 302.3.9 *Slides/slips/subsidence*

If slips, slides or subsidence occur in cuttings during the process of construction, they shall be removed at the cost of the Contractor as ordered by the Engineer. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction. If finished slopes slide into the roadway subsequently, such slides shall be removed and paid for at the Contract rate for the class of excavation involved, provided the slides are not due to any negligence on the part of the Contractor. The classification of the debris material from the slips, slides, etc. shall conform to its condition at the time of removal and payment made accordingly, regardless of its condition earlier.

### 302.3.10 *Drainage of excavated portion*

If water is met within the excavations due to springs, seepage from ponded water, rain or other causes, it shall be removed by suitable diversions, pumping or bailing out and the excavation kept dry whenever so required or directed by the Engineer. Care shall be taken to discharge the drained water into suitable outlets as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair/ restore to the original condition at his own cost or compensate for the damage.

### 302.3.11 *Disposal of excavated materials*

All the excavated materials shall be the property of the Employer. The material obtained from the excavation of roadway, shoulders, drains, cross-drainage works, etc. shall be used for filling-up of (i) roadway embankment (ii) the existing pits in the right-of-way and (iii) for landscaping of the road as directed by the Engineer, including levelling and spreading with all lifts and lead upto 1000 m and no extra payment shall be made for the same.

All hard materials, such as hard moorum, rubble, etc. not intended for use as above shall be stacked neatly on specified land as directed by the Engineer with all lifts and lead upto 1000 m.

Unsuitable materials shall be disposed of with all lifts and lead upto 1000 m as directed by the Engineer.

Transportation of serviceable excavated materials for use or disposal beyond initial 1000 m lead where required as directed by the Engineer shall be paid separately unless specified otherwise.

### 302.3.12 *Backfilling*

Backfilling of masonry/concrete/hume pipe drain excavation shall be done with approved material after concrete/masonry/hume pipe is fully set and carried out in such a way as not to cause undue thrust on any part of the structure and/or not to cause differential settlement. All space between the drain walls and the side of the excavation shall be refilled to the original surface making due allowance for settlement, in layers generally not exceeding 150 mm compacted thickness to the required density, using suitable compaction equipment such as mechanical tamper, power rammer, vibratory plate compactor, double-drum walk behind roller or any other appropriate equipment approved by the Engineer.

## 302.4 Plying of Construction Traffic

Construction traffic shall not use the cut formation and finished subgrade without the prior permission of the Engineer. Any damage arising out of such use shall be made good by the Contractor at his own cost.

## 302.5 Preservation of Roadside Drains and Structures

The Contractor shall undertake all reasonable precautions for the protection and preservation of any or all existing roadside trees, drains, pipes, conduits and any other structures under or above ground, which may be affected by construction operations and which, in the opinion of the Engineer, shall be continued in use without any change. Safety measures taken by the Contractor in this respect, shall be got approved from the Engineer. However, if any of these objects is damaged by reason of the Contractor's negligence, it shall be replaced or restored to the original condition at his cost. If the Contractor fails to do so, within the required time as directed by the Engineer or if, in the opinion of the Engineer, the actions initiated by the

Contractor to replace/restore the damaged objects are not satisfactory, the Engineer shall arrange the replacement/restoration directly through any other agency at the risk and cost of the Contractor after issuing a prior notice to the effect.

### 302.6 Preparation of Cut Formation

The cut formation, which serves as a subgrade, shall be prepared to receive the sub-base/ base course as directed by the Engineer.

Where the material in the subgrade (that is within 300 mm from the lowest level of the pavement) has a density less than 100 percent of Maximum Dry Density as per IS:2720 (Part 7), the same shall be loosened to a depth of 500 mm and compacted in layers in accordance with the requirements of Clause 301.5.6. Any unsuitable material (Clause 303.3) encountered in the subgrade shall be removed as directed by the Engineer and replaced with suitable material and compacted in accordance with Clause 301.5.6.

In rocky formations, the surface irregularities shall be corrected and the levels brought up to the specified elevation with granular base material as directed by the Engineer, laid and compacted in accordance with the respective Specifications for these materials. The unsuitable material shall be disposed of in accordance with Clause 302.3.11. After satisfying the density requirements, the cut formation shall be prepared to receive the sub-base/base course in accordance with Clause 303 to receive the sub-base/base course.

### 302.7 Finishing Operations

Finishing operations shall include the work of properly shaping and dressing all excavated surfaces.

When completed, no point on the slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock (hard or soft) where no point shall vary more than 300 mm from the designated slope. In no case shall any portion of the slope encroach on the roadway.

The finished cut formation shall satisfy the surface tolerances described in Section 1800.

Where directed, the topsoil removed earlier and conserved (Clauses 301.5.3 and 302.3.2) shall be spread over cut slopes, where feasible, berms and other disturbed areas. Slopes may be roughened and moistened slightly, prior to the application of topsoil, in order to provide satisfactory bond. The depth of topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 100 mm.

### 302.8 Measurements for Payment

Excavation for roadway shall be measured by taking cross-sections at suitable intervals in the original position before the excavation starts (after clearing and grubbing) and after its completion and computing the volumes in cubic metres by the method of average end areas for each class of material encountered. Where it is not feasible to compute volumes by this method because of erratic location of isolated deposits, the volumes shall be computed by other accepted methods.

At the option of the Engineer, the Contractor shall leave depth indicators during excavations of such shape and size and in such positions as directed so as to indicate the original ground level as accurately as possible. The Contractor shall see that these remain intact till the final measurements are taken.

For rock excavation, the overburden shall be removed first so that necessary cross-sections could be taken for measurement. Where cross-sectional measurements could not be taken due to irregular configuration or where the rock is admixed with other classes of materials, the volumes shall be computed on the basis of measurement of stacks of excavated rubble allowing 35 percent deduction therefrom. When volume is calculated in this manner for excavated material other than rock, a deduction to the extent of 16 percent of stacked volume shall be made.

Works involved in the preparation of cut formation shall be measured in units indicated below:

| | | |
|---|---|---|
| i) | Loosening and recompacting the loosened material at subgrade | cum |
| ii) | Loosening and removal of unsuitable material and replacing with suitable material and compacting to required density | cum |
| iii) | Preparing rocky subgrade | sqm |
| iv) | Stripping including storing and reapplication of topsoil | cum |
| v) | Disposal of surplus material beyond initial 1000 m lead | cum |
| vi) | Setting out | linear m |

### 302.9 Rate

**302.9.1** The Contract unit rates for the items of roadway and drain excavation shall be payment in full for carrying out the operations required for the individual items including full compensation for :

i) transporting the excavated materials for use, stacking or disposal as per Clause 302.3.11 with all lifts and lead upto 1000 m or as otherwise specified;

ii) trimming bottoms and slopes of excavation;

iii) dewatering;

iv) keeping the work free of water; and

v) all labour, materials, tools, equipment, safety measures, testing and incidentals necessary to complete the work to Specifications.

Where presplitting is prescribed to achieve a specified slope in rock excavation, the same shall be governed by Clause 304.3.4.

**302.9.2** The Contract unit rate for loosening and recompacting the loosened materials at subgrade shall include full compensation for loosening to the specified depth, including breaking clods, spreading in layers, watering where necessary and compacting to the requirements.

**302.9.3** Clauses 301.10 and 302.9.1 shall apply as regards Contract unit rate for item of removal of unsuitable material and replacement with suitable material respectively.

**302.9.4** The Contract unit rate for item of preparing rocky subgrade as per Clause 302.6 shall be full compensation for providing, laying and compacting granular base material for correcting surface irregularities including all materials, labour and incidentals necessary to complete the work and all leads and lifts.

**302.9.5** The Contract unit rate for the items of stripping and storing topsoil and of reapplication of topsoil shall include full compensation for all the necessary operations including all lifts, but leads upto 1000 m, or as otherwise specified.

**302.9.6** The contract unit rate for disposal of surplus earth from roadway and drain excavation shall be full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the initial lead of 1000 m, or as otherwise specified.

## 303 SUBGRADE CONSTRUCTION

### 303.1 Scope

These Specifications shall apply to the construction of subgrades, in embankments as well as in cut formations, with approved material obtained from roadway and drain excavation, borrow pits or other sources. All subgrades shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. Also included are the subgrades improved by way of treatment with lime/ cement as additives.

### 303.2 Definition of Subgrade

Subgrade is defined as the top 300 mm thick portion of the embankment, just beneath the pavement crust, providing a suitable foundation for the pavement. The subgrade in embankment is compacted in two layers usually to a higher standard than the embankment. In cuttings, the cut formation, which serves as the subgrade, is treated similarly to provide a suitable foundation for the pavement. Where the naturally occurring local subgrade soils have poor engineering properties and low strength in terms of CBR, for example in Black Cotton soil areas, improved subgrades are provided of selected material or local soils treated with lime/cement or other similar techniques.

### 303.3 Materials and General Requirements for Subgrades in Embankment

**303.3.1** *Physical requirements*

The materials used for subgrades in embankment shall be soil, moorum, gravel, a mixture of these or any other material approved by the Engineer. Expansive soils (un treated)and unsuitable materials as per Clause 301.2.3 shall not be used for subgrades.

**303.3.2** Where an expansive clay with acceptable 'free swelling index' value is used as a fill material in embankment, the subgrade and top 500 mm portion of the embankment just below the subgrade shall be non-expansive in nature.

**303.3.3** The size of the coarse material in the mixture or earth shall ordinarily not exceed 50 mm when placed in the subgrade. However, the Engineer may, at his discretion, permit the use of material coarser than this also, if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these Specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

**303.3.4** For use in the subgrade, any fill material which yields a maximum laboratory dry unit weight of less than 16.5 kN/m$^3$ when tested as per IS:2720 (Part 7) shall be considered unsuitable.

**303.3.5** *General requirements*

*303.3.5.1* The work shall be so planned that the best available materials are saved for the subgrade and the embankment portion just below the subgrade.

*303.3.5.2* The Contractor shall, at least 7 working days prior to commencement of subgrade construction submit to the Engineer for approval:

i) Soil classification test data

ii) The values of maximum dry density and optimum moisture content obtained in accordance with IS:2720 (Part 7) for each of the subgrade materials proposed to be used, together with the dry density - moisture content relationship graph.

iii) CBR tests conducted on samples at specified density and for soaked and unsoaked conditions for each of the subgrade materials, which should satisfy the design CBR requirement

The maximum dry density and optimum moisture content approved by the Engineer shall form the basis for compaction.

*303.3.5.3* For the subgrade, the degree of compaction shall be at least 100 percent of the maximum laboratory dry density as per IS:2720 (Part 7).

### 303.4 Materials and General Requirements for Subgrades in Cutting

Materials and requirements for subgrades in cutting or part cutting and part filling shall conform to Clause 303.3.

### 303.5 Construction Operations

**303.5.1** For setting out, dewatering, stripping of top soil, spreading, moisture control and compaction Clauses 301.5 shall apply except that each layer of the material in the subgrade shall be thoroughly compacted to at least 100 percent of maximum dry density as per IS:2720 (Part 7).

### 303.5.2 *Compacting surface supporting subgrade*

Where necessary, the original surface shall be levelled and compacted to at least 98 percent of maximum dry density as per IS:2720 (Part 7) to facilitate placement of first layer of subgrade,

In case where the difference between the subgrade level (top of the subgrade) and ground level is less than 0.3 m and the ground does not have the needed 100 percent relative compaction with respect to IS:2720 (Part 7), the ground shall be loosened upto a level 0.3 m below the subgrade level, watered and compacted in layers in accordance with Clause 301.5 to not less than 100 percent of the maximum dry density as per IS:2720 (Part 7).

Where so directed by the Engineer, any unsuitable material occuring in the embankment shall be removed and replaced to the specified depth by approved materials laid in layers to the required degree of compaction. Subgrade work shall not proceed until the embankment top 300 mm below the subgrade has been inspected by the Engineer for satisfactory compaction and approved.

### 303.5.3 *Improved subgrade construction*

Where improvement of weak subgrade soils (yielding very low soaked CBR values) is required by treating with additives like lime/lime+cement, any other approved additive, relevant provisions of Section 400 shall apply.

## 303.6 Subgrade Construction in Snow Bound Areas

Repeated freezing and thawing tends the soluble salts to move up due to capillary action, which causes hardening of bitumen due to chemical action of salts. Also, due to change in volume on freezing and thawing, the salts break up the pavement in cold regions. Wherever salt concentrations in excess of 0.2 percent are met with, a capillary cut-off in the form of a 100 mm compacted layer of coarse sand shall be provided in the subgrade to check the upward movement of the moisture from below.

## 303.7 Drainage

The surface of the embankment/subgrade at all times during construction shall be maintained at such a cross-fall (not flatter than that required for effective drainage of an earthen surface) as will shed water and prevent ponding.

## 303.8 Preparation of Cut Formation

The cut formation, which serves as a subgrade, shall be prepared, as per Clause 302.6, to receive the sub-base course as directed by the Engineer.

## 303.9 Subgrade Strength

**303.9.1** It shall be ensured, prior to actual execution that the borrow area material to be used in the subgrade satisfies the requirements of the design CBR.

**303.9.2** Subgrade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed subgrade shall be determined on remoulded samples, compacted to the field density at the field moisture content.

**303.9.3** Where the sub grade soil does not possess the requisite properties or yields very low CBR values or fails to meet the desire CBR value, the soil properties and strength shall be improved to meet the design requirement by an appropriate stabilization technique as specified in the contract or directed by the Engineer. Section 400 and IRC:SP:89 shall apply in this regard. The subgrade strength shall be determined from improved subgrade soil samples in terms of CBR or UCS values, as may be relevant.

### 303.10 Measurements for Payment

**303.10.1** In the case of subgrades in embankment, Clause 301.14 shall apply except that the work will be restricted to 300 mm depth below the finished formation level.

**303.10.2** In the case of subgrades in cut formation, Clause 302.8 shall apply.

**303.10.3** Stabilized soil subgrade shall be measured as finished work in position.

### 303.11 Rate

**303.11.1** In the case of subgrades in embankment, Clause 301.15 shall apply except that the work will be restricted to 300 mm depth below the finished formation level.

**303.11.2** In the case of subgrades in cut formation, the rate shall be included in the rate for Earthwork in Cutting (Clause 302.9) and shall not be paid separately.

**303.11.3** The contract unit rate for stabilized subgrade shall be payment in full for carrying out the required operations including full compensation for all components required.

## 304 ROCK CUTTING

### 304.1 Scope

This Specification provides detailed guidelines on various aspects of blasting operations involved in rock cutting. It also covers ‘presplitting’, defined as the establishment of a specified excavation slope in rock by the controlled use of explosives and blasting accessories in properly aligned and spaced drill holes. The presplitting technique shall be used for forming rock excavation slopes at locations shown on the plans or as otherwise decided by the Engineer.

### 304.2 Guidelines on Blasting Operations

#### 304.2.1 *General*

Blasting shall be carried out in a manner that completes the excavation to the lines indicated in drawings, with the least disturbance to adjacent material. It shall be done only with the written permission of the Engineer. All the statutory laws, regulations, rules, etc. pertaining to the acquisition, transport, storage, handling and use of explosive shall be strictly followed. A Note on the Safety Aspects is given at **Annexure-300.2**.

The Contractor may adopt any method or methods of blasting consistent with the safety and job requirements. Prior to starting any phase of the operation, the Contractor shall provide information describing pertinent blasting procedures, dimensions and notes.

The magazine for the storage of explosives shall be built to the designs and specifications of the Explosives Department concerned and located at the approved site. No unauthorized person shall be admitted into the magazine which, when not in use, shall be kept securely locked. No matches or inflammable material shall be allowed in the magazine. The magazine shall have an effective lightning conductor. The following shall be hung in the lobby of the magazine:

a) A copy of the relevant rules regarding safe storage both in English and in the language with which the workers concerned are familiar.

b) A statement of up-to-date stock in the magazine.

c) A certificate showing the last date of testing of the lightning conductor.

d) A notice that smoking is strictly prohibited.

All explosives shall be stored in a secure manner in compliance with all laws and ordinances, and all such storage places shall be clearly marked. Where no local laws or ordinances apply, storage shall be provided to the satisfaction of the Engineer and in general not closer than 300 m from the road or from any building or camping area or place of human occupancy. In addition to these, the Contractor shall also observe the following instructions and any further additional instructions which may be given by the Engineer and shall be responsible for damage to property and any accident which may occur to workmen or the public on account of any operations connected with the storage, handling or use of explosives and blasting. The Engineer shall frequently check the Contractor's compliance with these precautions.

### **304.2.2** *Materials, tools and equipment*

All the materials, tools and equipment used for blasting operations shall be of approved type. The Engineer may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be sufficiently water-resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as will permit sufficient time to the firer to reach safety before explosion takes place. Detonators shall be capable of giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc. shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed from the site immediately.

### **304.2.3** *Personnel*

The blasting operation shall remain in the charge of competent and experienced supervisor and workmen who are thoroughly acquainted with the details of handling explosives and blasting operations.

### 304.2.4 *Blasting operations*

The blasting shall be carried out during fixed hours of the day, preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the man in charge only.

The Contractor shall notify each public utility company having structures in proximity to the site of the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury. In advance of any blasting work within 50 m of any railway track or structures, the Contractor shall notify the concerned Railway Authority of the location, date, time and approximate duration of such blasting operations.

Red danger flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area, and all persons including workmen shall be excluded from the flagged area at least 10 minutes before the firing, a warning siren being sounded for the purpose.

The charge holes shall be drilled to required depths and at suitable places. Blasting should be as light as possible, consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshooting shall be discontinued.

When blasting is done with powder, the fuse cut to the required length shall be inserted into the hole and the powder dropped in. The powder shall be gently tamped with copper rods with rounded ends. The explosive powder shall then be covered with tamping material which shall be tamped lightly but firmly.

When blasting is done with dynamite and other high explosives, dynamite cartridges shall be prepared by inserting the square cut end of a fuse into the detonator and finishing it with nippers at the open end, the detonator gently pushed into the primer leaving 1/3rd of the copper tube exposed outside. The paper of the cartridge shall then be closed up and securely bound with wire or twine. The primer shall be housed into the explosive. Boreholes shall be of such size that the cartridge can easily go down. The holes shall be cleared of all debris and explosive inserted. The space of about 200 mm above the charge shall then be gently filled with dry clay, pressed home and the rest of the tamping formed of any convenient material gently packed with a wooden rammer.

At a time, not more than 10 such charges will be prepared and fired. The man in charge shall blow a siren in a recognised manner for cautioning the people. All the people shall then be required to move to safe distances. The charges shall be lighted by the man-in-charge only. The man-in-charge shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workmen to go back to the work site.

After blasting operations, the Contractor shall compact the loose residual material below subgrade and replace the material removed below subgrade with suitable material.

### 304.2.5 *Misfire*

In case of misfire, the following procedure shall be observed:

i) Sufficient time shall be allowed to account for the delayed blast. The man-in-charge shall inspect all the charges and determine the missed charge.

ii) If it is the blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. Should it not blast the old charge, the procedure shall be repeated till the old charge is blasted.

iii) In case of charges of gelignite, dynamite, etc., the man-in-charge shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 300 mm of tamping and the direction then ascertained by placing a stick in the hole. Another hole may then be drilled 150 mm away and parallel to it. This hole shall then be charged and fired when the misfired hole should explode at the same time. The man-in-charge shall at once report to the Contractor's office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith.

If a misfire has been found to be due to defective detonator or dynamite, the whole quantity in the box from which defective article was taken must be sent to the authority directed by the Engineer for inspection to ascertain whether all the remaining materials in the box are also defective.

### 304.2.6 *Account*

A careful and day-to-day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer at all times.

## 304.3 **Presplitting Rock Excavation Slopes**

### 304.3.1 Construction operations

Prior to starting operations for presplitting, the Contractor shall furnish the Engineer a plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing. The drilling and blasting plan is for record purposes only and will not absolve the Contractor of his responsibility for using proper drilling and blasting procedures. Controlled blasting shall begin with a short test section of a length approved by the Engineer. The test section shall be presplit, production drilled and blasted and sufficient material excavated whereby the Engineer can determine if the Contractor's methods have produced an acceptable slope.

All overburden soil and weathered rock along the top of the excavation for a distance of about 5 to 15 m beyond the drilling limits, or to the end of the excavation, as decided by the

Engineer shall be removed before drilling the presplitting holes. Particular care and attention shall be directed to the beginning and end of excavations to ensure complete removal of all overburden soil and weathered rock and to expose fresh rock to an elevation equal to the bottom of the adjacent lift of the presplitting holes being drilled.

Slope holes for presplitting shall be drilled along the line of the planned slope within the specified tolerances. The drill holes shall be not less than 60 mm nor more than 75 mm in diameter. Drilling operations shall be controlled by the use of proper equipment and technique to ensure that no hole shall deviate from the plane of the planned slope by more than 300 mm nor shall any hole deviate from being parallel to an adjacent hole by more than two-third of the planned horizontal spacing between holes.

The length of presplit holes shall not exceed 900 mm on centres and shall be adjusted to result in a uniform shear face between holes.

Auxiliary drill holes along the presplit line, not loaded or stemmed, may be ordered by the Engineer. Except for spacing, auxiliary drill holes shall conform to the provisions for presplit holes.

The line of production holes shall be placed inside the presplit lines in such a manner as to avoid damage to the presplit face.

If necessary, to reduce shatter and overbreak of the presplit surface, the first line of the production holes shall be drilled parallel to the slope line at the top of the cut and at each bench level thereafter.

Any blasting technique, which results in damage to the presplit surface, shall be immediately discontinued.

No portion of any production hole shall be drilled within 2.5 m of a presplit plane except as approved by the Engineer. The bottom of the production holes shall not be lower than the bottom of the presplit holes.

A maximum offset of 600 mm will be permitted for a construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern. The drilling operations shall be adjusted to compensate for drift of previous levels and for the offset at the start of new levels to maintain the specified slope plane.

The maximum diameter of explosives used in presplit holes shall not be greater than one-half the diameter of the presplit hole.

Only standard cartridge explosives prepared and packaged by explosive manufacturing firms shall be used in presplit holes. These shall be fired as recommended by the manufacturer. Ammonium nitrate composition blasting agents will not be permitted in presplitting operations.

Stemming may be required to achieve a satisfactory presplit face. Stemming material shall be dry free-running material all of which passes 11.2 mm sieve and 90 percent of which is retained on 2.80 mm sieve. Stemmed presplit holes shall be completely filled to the collar.

All charges in each presplitting pattern shall be detonated simultaneously.

### 304.3.2 *Tolerances*

The presplit face shall not deviate more than 300 mm from the plane passing through adjacent drill holes, except where the character of the rock is such that, as determined by the Engineer, irregularities are unavoidable. When completed, the average plane of the slopes shall conform to the slopes indicated on the plans and no point on the completed slopes shall vary from the designated slopes by more than 300 mm. These tolerances shall be measured perpendicular to the plane of the slope. In no case shall any portion of the slope encroach on the side drains.

As long as equally satisfactory presplit slopes are obtained, then either the slope face may be presplit before drilling for production blasting or presplitting the slope face and production blasting may be done at the same time, provided that the presplitting drill holes are fired with zero delay and the production holes are delayed starting at the row of holes farthest from the slope and progressing in steps to the row of holes nearest the presplit line, which row shall be delayed at least 50 milliseconds. In either case, the presplitting holes shall extend either to the end of the excavation or for a distance of not less than 15 m beyond the limits of the production holes to be detonated.

### 304.3.3 *Measurements for payment*

The area of presplitting to be paid for will be measured as square metres of acceptable presplit slope surface.

### 304.3.4 *Rate*

The Contract unit rate for presplitting work shall be payment in full for carrying out the required operations for obtaining acceptable presplit slope surfaces. The quantity of rock excavated through the production/presplit holes shall be paid for as per Clause 302.9.1.

## 305 EXCAVATION FOR STRUCTURES

### 305.1 Scope

This work shall consist of excavation for the construction of foundations for cross-drainage structures, retaining walls, headwalls and other similar structures, in accordance with the requirements of these Specifications and the lines and dimensions shown on the drawings or as directed by the Engineer. The work shall include construction of the necessary sheeting, bracing, shoring, draining and pumping, removal of all logs, stumps and other deleterious matter and obstructions necessary for placing the foundations, trimming bottoms of excavations, backfilling and clearing up the site and the disposal of all surplus material.

### 305.2 Classification of Excavation

The classification of all materials involved in excavation shall be as per Clause 302.2.1 and Annexure-300.1.

### 305.3 Construction Operations

### 305.3.1 *Setting out*

The site shall be cleared as per Section 200 and the limits of excavation shall be set out true to lines, curves and slopes as per Section 100.

### 305.3.2 *Width of excavation*

The width of excavation shall be the width of the lowest step of the footing and the sides shall be left vertical where the nature of soil permits. However, if the nature of soils or depth of the trench and season of the year do not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

### 305.3.3 *Depth of excavation*

The depth of excavation shall be as shown on the drawings, unless the type of material encountered is such as to require changes in which case the depth shall be as ordered by the Engineer. Propping shall be undertaken when any foundation or stressed zone from an adjoining structure is within a line of 1:2 from the bottom of the excavation.

### 305.3.4 *Blasting operations*

Where blasting is to be resorted to, the same shall be carried out in accordance with Clause 304 and all precautions as given therein shall be observed. Where blasting is likely to endanger adjoining foundations or other structures, necessary precautions such as controlled blasting, providing rubber mat cover to prevent flying of debris, etc. shall be taken to prevent any damage.

### 305.3.5 *Dewatering*

Where water is met with in excavation due to stream flow, seepage, rain or other reasons, the Contractor shall take adequate measures such as pumping, constructing diversion channels, bunds and other necessary works to keep the foundation trenches dry when so required and to protect the green concrete/masonry against damage by erosion or sudden rising of water level. The methods to be adopted in this regard and other details thereof shall be left to the choice of the Contractor but subject to approval of the Engineer. Approval of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works. Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping shall be permitted during the placing of concrete or for any period of at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall or other similar means.

The Contractor shall take all precautions in diverting channels and in discharging the drained water as not to cause damage to the works, crops or any other property.

### 305.3.6 *Foundation preparation*

The bottom of the foundation shall be levelled both longitudinally and transversally or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed. In case the excavation has been made deeper than that shown on the drawings or as otherwise ordered by the Engineer, the extra depth shall be made up with concrete or masonry of the foundation at the cost of the Contractor; ordinary filling shall not be used for the purpose.

When rock or other hard rock stratum is encountered, it shall be freed of all soft and loose material, cleaned and cut to a firm surface either level or stepped as directed by the Engineer. All seams and crevices shall be cleaned and filled with cement mortar or grout to the satisfaction of the Engineer. In the case of excavation in rock, annular space around footing shall be filled with lean concrete (1:3:6 nominal mix) upto the top level of rock. If the depth of fill required is more than 1.5 m above the top of the footing, filling upto 1.5 m above top of the footing shall be done with lean concrete (1:3:6 nominal mix) followed by boulders grouted with cement.

### 305.3.7 *Slips/slip-outs*

If there are any slips or slip-outs in the excavation, these shall be removed by the Contractor at his own cost.

### 305.3.8 *Public safety*

Near towns, villages and all frequented places, trenches and foundation pits shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accidents. The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures. For safety precautions, guidance may be taken from IS:3764.

### 305.3.9 *Backfilling*

Backfilling shall be done with approved material after concrete or masonry is fully set and carried out in such a way as not to cause undue thrust on any part of the structure. All space between foundation masonry or concrete and the sides of excavation shall be refilled to the original surface in layers not exceeding 150 mm compacted thickness. The compaction shall be done with the help of suitable equipment such as mechanical tamper, rammer, plate vibrator, etc. after necessary watering, so as to achieve a density not less than the field density before excavation.

### 305.3.10 *Disposal of surplus excavated materials*

Clause 302.3.11 shall apply.

## 305.4 **Measurements for Payment**

Excavation for structures shall be measured in cubic metres for each class of material encountered, limited to the dimensions shown on the drawings or as directed by the Engineer. Excavation over increased width, cutting of slopes, shoring, shuttering and planking shall be deemed to be incidental to the work and shall not be measured and paid for separately.

Preparation of rock foundation shall be measured in square metres. Foundation sealing, dewatering, including pumping shall be deemed to be incidental to the work unless separate provision is made for it in the contract.

## 305.5 **Rate**

**305.5.1** The Contract unit rate for the items of excavation for structures shall be payment in full for carrying out the required operations including full compensation for :

i) setting out;

ii) construction of necessary sheeting, shoring and bracing and their subsequent removal;

iii) removal of all logs, stumps, grubs and other deleterious matter and obstructions, for placing the foundation including trimming of bottoms of excavations;

iv) foundation sealing, dewatering including pumping, when no separate provision for it is made in the Contract;

v) backfilling, clearing up the site and disposal of all surplus material within all lifts and leads upto 1000 m or as otherwise specified; and

vi) all labour, materials, tools, equipment, safety measures, diversion of traffic and incidentals necessary to complete the work to Specifications.

**305.5.2** The Contract unit rate for preparation of rock foundation shall be full compensation for cutting, trimming and cleaning the foundation surface; and filling/sealing of all seams with cement grout or mortar including all materials, labour, and incidentals required for completing the work.

**305.5.3** The Contract unit rate for transporting materials from the excavation for structures shall be full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the initial lead of 1000 m.

## 306 FLYASH EMBANKMENT CONSTRUCTION

### 306.1 Scope

This Specification shall apply to the construction of flyash embankments, with an appropriate soil cover, in accordance with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 306.2 Materials for Construction

### 306.2.1 *Flyash*

Flyash for embankment construction shall conform to the geotechnical and chemical properties specified in IRC:SP:58 “Guidelines for Use of Flyash in Road Construction”. The term flyash shall cover all types of coal ash such as pond ash, bottom ash or mound ash. The test results and the following information for the flyash to be used in embankment construction shall be made available for the Engineer’s approval :

i) Particle size analysis of the material as per wet sieve analysis

ii) Maximum Dry Density and Optimum Moisture Content as per IS:2720 (Part 7) along with the graph of dry density plotted against moisture content, which shall form the basis for compaction.

### 306.2.2 *Soil*

The material for soil cover shall conform to the requirements of Clause 301.3.

## 306.3 Construction Operations

### 306.3.1 *Setting out*

Clause 301.5.1 shall apply.

### 306.3.2 *Dewatering*

Clause 301.5.2 shall apply.

### 306.3.3 *Stripping of topsoil*

Clause 301.5.3 shall apply.

### 306.3.4 *Preparing foundation for embankment*

Clause 301.5.4 shall apply.

### 306.3.5 *Handling flyash*

The flyash from hoppers or silos shall be conditioned with water at the power plant to prevent dusting enroute and causing environmental pollution. Flyash shall be delivered to the site in covered dump trucks to minimize loss of moisture and dusting. Stockpiling of flyash at the construction site shall be avoided. In case temporary stockpiling at site becomes inevitable, precautions shall be taken to prevent dusting by spraying water on stockpiles at regular intervals or the surface of the flyash stockpile shall be covered with tarpaulins or a thin layer of soil or other granular material not subject to dusting, as directed by the Engineer. Traffic movements shall be restricted to those areas which are kept moist, to prevent the dust nuisance.

### 306.3.6 *Spreading, moisture control and compaction*

#### *306.3.6.1* Spreading

The side soil cover, of required width shall be provided, along with the flyash core, and mechanically compacted as the embankment progresses upwards; the addition of side cover subsequent to the construction of the flyash core shall not be permitted. The fill material shall preferably be spread by mechanical means in the specified slope and grade. For small jobs, manual methods may be permitted by the Engineer. When compaction is to be carried out using a static roller of 80 to 100 kN weight, the loose layer thickness shall not exceed 200 mm. Where vibratory rollers of 80 to 100 kN weight are used, loose layer thickness upto 400 mm can be adopted if site trials show satisfactory compaction.

The cover soil and flyash shall be laid simultaneously before compaction, to ensure confinement of flyash. Clods in cover soil shall be broken to have a maximum size of 50 mm.

### 306.3.6.2 *Moisture control*

The moisture content of the fill material shall be checked at the site of placement prior to the commencement of compaction. Normally, the moisture content of flyash laid for compaction shall be within ± 2 percent of the Optimum Moisture Content when determined as per IS:2720 (Part 7). However, the moisture content limits can be varied by the Engineer, depending on the weather conditions prevailing at the site, provided specified compaction is achieved as determined by actual site trials. Moisture content of the cover soil shall be maintained near its Optimum Moisture Content.

Where water is required to be added to the fill material, it shall be sprinkled from a water bowser fitted with a sprinkler capable of applying water uniformly without flooding. The water shall be mixed thoroughly by blading, discing or harrowing or by manual means as directed by the Engineer, until uniform moisture content is obtained throughout the depth of the layer. If the material delivered to the construction site is too wet, it shall be dried by aeration and exposure to the sun, till it is acceptable for compaction.

### 306.3.6.3 *Compaction*

Flyash shall be compacted using static or vibratory rollers, as directed by the Engineer. Regardless of the equipment, flyash must be compacted as early as possible after spreading. The Contractor shall demonstrate the efficacy of the equipment he intends to use by carrying out compaction trials. Each layer of flyash shall be thoroughly compacted to the specified density. When vibratory roller is adopted for compaction, two passes without vibration followed by 5 to 8 passes with vibration shall normally be sufficient to compact each layer.

The compaction of flyash core and soil cover on the sides shall proceed simultaneously. Each compacted layer shall be finished parallel to the final cross-section of the embankment. The end product specifications for the construction of flyash embankments shall be as under:

- Minimum dry density after compaction as percentage of maximum dry density determined as per IS:2720 (Part 7) : 98 percent
- Minimum dry density after compaction when used behind bridge abutments for embankment length equal to 1.5 times the height of the embankment : 100 percent of max dry density.

Subsequent layers shall be placed only after the finished layer has been tested for its density requirements. The Contractor shall maintain a record of all such tests. When density measurements reveal any soft areas in the embankment, further compaction shall be carried out as directed by the Engineer. Inspite of that, if the specified degree of compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, moisture content brought to permissible limits and recompacted to the required density. The embankment shall be constructed evenly over full width and the Contractor shall control and direct construction plant or other vehicular traffic uniformly across the width. Damage by the construction plant or other vehicular traffic shall be made good by the Contractor at his cost to original specifications. Whenever embankment construction is to be taken-up against the face of natural slope or sloping earth works face including embankments, cuttings and excavations which are steeper than 1:4, such faces shall be benched immediately before placing the subsequent fill.

### 306.4 Soil Subgrade

On the top of the flyash embankment, at least 500 mm thick earth embankment shall be provided out of which top 300 mm thick shall be subgrade as per Clause 303 of these Specifications.

### 306.5 Finishing Operations

Clause 301.6 shall apply.

Embankments in flood prone areas shall be protected by stone pitching where specified.

### 306.6 Settlement Period

Clause 301.11 shall apply.

### 306.7 Plying of Traffic

Clause 301.12 shall apply.

### 306.8 Surface Finish and Quality Control of Work

Clause 301.13 shall apply.

### 306.9 Measurements for Payment

Clause 301.14 shall apply.

### 306.10 Rate

Clause 301.15 shall apply.

## 307 SURFACE DRAINS

### 307.1 Scope

This work shall consist of constructing surface drains in accordance with the requirements of these specifications and to the lines, grades, dimensions and other particulars shown on the drawings or as directed by the Engineer. Schedule of work shall be so arranged that the drains are completed in proper sequence with road works to ensure that no excavation of the completed road works is necessary subsequently or any damage is caused to these works due to lack of drainage.

### 307.2 Surface Drains

Surface drains shall be excavated to the specified lines, grades, levels and dimensions to the requirements of Clause 302. The excavated material shall be removed from the area adjoining the drains and if found suitable, utilised in embankment/subgrade construction. All unusable material shall be disposed of as directed.

The excavated bed and sides of the drains shall be dressed to bring these in close conformity with the specified dimensions, levels and slopes.

Where so indicated, drains shall be turfed or lined with suitable materials in accordance with details shown on the drawings.

All works on drain construction shall be planned and executed in proper sequence with other works as approved by the Engineer, with a view to ensuring adequate drainage for the area and minimizing erosion/ sedimentation.

### 307.3 Measurements for Payment

Measurement for surface drains shall be per running metre length of the drain. Disposal of surplus material beyond 1000 m shall be measured in cubic metres.

### 307.4 Rate

The Contract unit rates for surface drains shall be payment in full for all items, such as, excavation, dressing the sides and bottom; providing lining, turfing, pitching, masonry, concrete and plastering, etc. including full compensation for all materials, labour, tools and other incidentals to complete the work as shown on the drawings with all leads and lifts except for removal of unsuitable material for which the lead shall be 1000 m. Provision of inlets, outlets, etc. whenever required shall be incidental to construction of drain. The Contract unit rate for disposal of surplus and unsuitable material beyond the initial 1000 m lead shall be in accordance with Clause 305.5.3.

## 308 SOIL EROSION AND SEDIMENTATION CONTROL

### 308.1 Scope

This work shall consist of measures as shown on drawings or as directed by the Engineer to control soil erosion, sedimentation and water pollution, through use of berms, mulches, grasses, slope drains and other devices.

### 308.2 Materials

All materials shall meet commercial grade standards and shall be approved by the Engineer before being used in the work.

### 308.3 Construction Operations

Prior to the start of the relevant construction, the Contractor shall submit to the Engineer for approval, his schedules for carrying out temporary and permanent erosion/sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/subgrade construction, cross-drainage structures, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion/ sedimentation control on borrow pits and his plan for disposal of materials. Work shall not be started until the erosion/ sedimentation control schedules and methods of operations for the applicable construction have been approved by the Engineer.

The surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill operations shall be limited to the extent practicable. The Contractor may be directed to provide immediate permanent or temporary erosion and sedimentation control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other water courses, lakes, reservoirs, etc. Such work may involve the construction of temporary berms, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation. Cut and fill slopes shall be seeded and turfed as shown on the drawings.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

Temporary erosion and pollution control measures will be used to control the phenomenon of erosion and pollution that may develop during normal construction practices, but may neither be foreseen during design stage nor associated with permanent control features on the project.

Under no conditions shall a large surface area of erodible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the Engineer.

The Engineer may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion/sedimentation control measures shall be taken immediately to the extent feasible and justified.

In the event temporary erosion, sedimentation and pollution control measures become necessary due to the Contractor's negligence, carelessness or failure to install permanent controls as a part of the work as scheduled or ordered by the Engineer, these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the Engineer.

Temporary erosion, sedimentation and pollution control may include construction work outside the right-of-way where such work is necessary as a result of road construction such as borrow pit operations.

The temporary erosion, sedimentation and pollution control features installed by the Contractor shall be acceptably maintained by him till these are needed, unless otherwise agreed by the Engineer.

### 308.4 Measurements for Payment

The soil erosion, sedimentation and pollution control works shall be measured in terms of units specified in the Bill of Quantities for the respective items.

### 308.5 Rate

The Contract unit rate for different items of soil erosion, sedimentation and pollution control works shall be payment in full for carrying out all required operations including full compensation for all labour, materials, tools, equipment and incidentals to complete the works to the Specifications.

## 309 TURFING WITH SODS

### 309.1 Scope

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on embankment slopes, verges (earthen shoulders) or other locations shown on the drawings or as directed by the Engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment, provided the season is favourable for establishment of the sod.

### 309.2 Materials

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be used, and shall be practically free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm and the sod shall have been freed of debris.

Thickness of the sod shall be as uniform as possible, with some 50-80 mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm x 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

### 309.3 Construction Operations

#### 309.3.1 *Preparation of the earth bed*

The area to be sodded shall have been previously constructed to the required slope and cross-section. Soil on the area shall be loosened, freed of all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25 mm for receiving the sod.

Where required, topsoil shall be spread over the slopes. Prior to placing the topsoil, the slopes shall be scarified to a depth which, after settlement, will provide the required nominal depth shown on the drawings. Spreading shall not be done when the ground is excessively wet.

Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the plans. After spreading, the materials are incorporated in the soil by discing or other means to the depths shown on the plans.

### 309.3.2 *Placing the sods*

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same had been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

On side slopes steeper than 2 (horizontal) to 1 (vertical), the laying of sods shall be started from bottom upwards. At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its thorough compaction.

### 309.3.3 *Staking the sods*

Where the side slope is 2 (horizontal) to 1 (vertical) or steeper and the distance along the slope is more than 2 m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000 mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

### 309.3.4 *Top dressing*

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter, a thin layer of topsoil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water.

### 309.3.5 *Watering and maintenance*

The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks.

The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance.

## 309.4 **Measurements for Payment**

Turfing with sods shall be measured as finished work in square metres.

## 309.5 **Rate**

The Contract unit rate for turfing with sods shall mean payment in full for carrying out all the required operations explained above including compensation for

i) furnishing all the materials to be incorporated in the Works with all leads and lifts; and

ii) all labour, tools, equipments and incidentals to complete the work in accordance with these Specifications.

The Contract unit rate for application of topsoil shall be as per Clause 302.9.5.

## 310 SEEDING AND MULCHING

### 310.1 Scope

This work shall consist of preparing slopes, placing topsoil, furnishing all seeds, commercial or organic fertilizers and mulching materials, providing jute netting, coir netting or polymer netting and placing and incorporating the same on embankment slopes or other locations designated by the Engineer or shown on the drawings

### 310.2 Materials

a) **Seeds:** The seeds shall be of approved quality and type suitable for the soil on which these are to be applied, and shall have acceptable purity and germination to requirements set down by the Engineer.

Fertilizer shall consist of standard commercial materials and conform to the grade specified. Organic manure shall be fully putrefied organic matter, such as, cow dung.

Mulching materials shall consist of straw, hay, wood shavings or sawdust, and shall be delivered in dry condition. They shall be reasonably free of weed seed and such foreign materials as may detract from their effectiveness as mulch or be injurious to the plant growth.

b) **Topsoil:** Topsoil shall not be obtained from an area known to have noxious weeds growing in it. If treated with herbicides or sterilents, it shall be got tested by appropriate agricultural authority to determine the residual in the soil. Topsoil shall not contain less than 2 percent and more than 12 percent organic matter.

c) **Bituminous Emulsion:** A suitable grade of bituminous cutback or emulsion used as a tie down for mulch shall be as described in the Contract document or as directed by the Engineer. Emulsified bitumen shall not contain any solvent or diluting agent toxic to plant life.

d) **Netting:** Jute netting shall be undyed jute yarn woven into a uniform open weave with approximate 25 mm square openings.

Geonetting shall be made of uniformly extruded rectangular mesh having mesh opening of 20 mm x 20 mm. The colour may be black or green. It shall weigh not less than 3.8 kg per 1000 sqm.

## 310.3 Seeding Operations

### 310.3.1 *Seed-bed preparation*

The area to be seeded shall be brought to the required slope and cross-section by filling, reshaping eroded areas and refinishing slopes, medians, etc. Topsoil shall be evenly spread over the specified areas to the depth shown on the drawings, unless otherwise approved by the Engineer. The seed-bed preparation shall consist of eliminating all live plants by suitable means using agricultural implements. All stones 150 mm in smallest dimension and larger shall be removed. The soil shall be excavated on the contour to a depth of 100 mm. All clods larger than 25 mm in diameter shall be crushed and packed. Where necessary, water shall then be applied. All topsoil shall be compacted unless otherwise specified or approved by the Engineer. Compaction shall be by slope compactor, cleated tractor or similar equipment approved by the Engineer. Equipment shall be so designed and constructed as to produce a uniform rough textured surface ready for seeding and mulching and which will bond the topsoil to the underlying material. The entire area shall be covered by a minimum of 4 passes or 2 round trips of the roller or approved equipment.

### 310.3.2 *Fertilizer application*

Fertilizer to the required quantities shall be spread and thoroughly incorporated into the soil surface as a part of the seed-bed preparation.

### 310.3.3 *Planting of seeds*

All seeds shall be planted uniformly at the approved rate. Immediately after sowing, the area shall be raked, dragged or otherwise treated so as to cover the seeds to a depth of 6 mm.

The operation of seed sowing shall not be performed when the ground is muddy or when the soil or weather conditions would otherwise prevent proper soil preparation and subsequent operations.

### 310.3.4 *Soil moisture and watering requirements*

Soil-moisture shall exist throughout the zone from 25 mm to at least 125 mm below the surface at the time of planting.

Watering of the seeded areas shall be carried out as determined by the Engineer.

## 310.4 Mulching, Applying Bituminous Emulsion and Jute Netting/Geonetting/Netting of Coir

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed so as to form a continuous, unbroken cover of approximate uniform thickness of 25 mm using an acceptable mechanical blower. Mulching material shall be held in place and made resistant to being blown away by suitable means approved by the Engineer. Where specified, mulch material shall be anchored in place with bituminous emulsion applied at the rate of 2300 litres per hectare. Any mulch disturbed or displaced following application shall be removed, reseeded and remulched as specified. Jute netting/Geonetting/Coir netting shall be unrolled and placed parallel to the flow of water immediately following the bringing, to finished grade, the area specified on the drawings or the placing of seed and fertilizer. Where more than one strip is required to cover the given areas, they shall overlap a minimum of 100 mm. Jute netting/Geonetting/Coir netting shall be held in place by approved wire staples, pins, spikes or wooden stakes driven vertically into the soil.

### 310.5 Maintenance

The Contractor shall maintain all seeded and mulched areas until final acceptance. Maintenance shall include protection of traffic by approved warning signs or barricades and repairing any areas damaged following the seeding and mulching operations. If mulched areas become damaged, the area shall be reshaped and then seeded and mulched again as originally specified.

### 310.6 Measurements for Payment

Seeding and mulching shall be measured as finished work in square metres.

### 310.7 Rate

The Contract unit rate for seeding and mulching shall be payment in full for carrying out all the required operations including full compensation for all materials, labour, tools and incidentals.

## Annexure – 300.1

(Refer : Clause 302.2.1)

## CLASSIFICATION OF EXCAVATED MATERIAL

### a) Soil

This shall comprise topsoil, turf, sand, silt, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick, spade and/or shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having dimension in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

### b) Ordinary Rock (not requiring blasting)

This shall include:

i) rock types such as laterites, shales and conglomerates, varieties of limestone and sandstone, etc. which may be quarried or split with crow bars, also including any rock which in dry state may be hard, requiring blasting but which, when wet, becomes soft and manageable by means other than blasting;

ii) macadam surfaces such as water bound and bitumen/tar bound; soling of roads, cement concrete pavement, cobble stone, etc.; compact moorum or stabilised soil requiring use of pick axe and shovel.

iii) lime concrete, stone masonry and brick work in lime/ cement mortar below ground level, reinforced cement concrete which may be broken-up with crow bars or picks.

iv) boulders which do not require blasting found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin.

### c) Hard Rock (requiring blasting)

This shall comprise :

i) any rock or cement concrete or reinforced cement concrete for the excavation of which the use of mechanical plant and/or blasting is required;

ii) boulders requiring blasting.

### d) Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under (c) but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

### e) Marshy Soil

This shall include soils like soft clays and peats excavated below the original ground level of marshes and swamps and soils excavated from other areas requiring continuous pumping or bailing out of water.

## Annexure – 300.2

(Refer : Clause 304.2.1)

## A NOTE ON SAFETY ASPECTS IN BLASTING

Safety in blasting is mostly common sense with a knowledge of the dangers associated with explosives if misused. Explosives have a wide variety of uses and the development of an accident-free routine is complicated by the large number of wide-spread centres of use.

Because of the large potential energy content of explosives and the damage which can result from an accidental detonation, the need for caution in their use must be obvious. The majority of high explosives require a severe shock before detonating and consequently can be handled with care. Detonators are most susceptible to accidental initiation from shock or fire although this tendency has been reduced in recent years. Fire will probably cause detonators to explode and high explosive to burn and possibly explode.

### 1. SUPERVISION

With any safety programme both training and supervision are vital. The training should impart a knowledge of the various explosives and accessories, their use in practice and the routine to be adopted for their safe use. Supervision must follow training to ensure that correct procedures are used and safety requirements are strictly enforced. A suitably trained shot-firer must be employed for all blasting.

### 2. PRECAUTIONS

This will briefly outline the fundamental requirements for the use of explosives.

### 2.1 Storage

This is important not only from the aspect of safety to the general public but also to prevent deterioration of the materials due to heat, cold or moisture. Explosives must be stored in approved magazines which must be securely locked except when removing or replacing stocks. Amongst the storage requirements are :

2.1.1 A magazine keeper must be appointed and he is responsible for the upkeep and control of the magazine and contents.

2.1.2 A magazine book must be kept in the magazine to enable a check to be made on the issue and receipt of high explosives and detonators.

2.1.3 High explosives and detonators are not to be stored together.

2.1.4 The magazine must be kept clean, dry and cool inside and the area for 10 m around must be cleared of vegetation and rubbish at all times. The magazines must be efficiently marked.

2.1.5 All explosives not being used must be kept in a magazine. Many accidents have resulted from unauthorized people (including children) picking-up and misusing explosives. Explosives (including detonators) are not to be carried in clothing or left lying about camp sites, job sites or in vehicles.

2.1.6 Ammonium nitrate does not have to be stored in a magazine but it must be protected from heat and moisture.

2.1.7 For the storage of high explosive like Ammonium Nitrate + Fuel Oil (AN/FO), when required, permission must be obtained from the Chief Inspector of Explosives.

### 2.2 Transport

The transport of explosives between the magazine and the job site is a necessary part of most excavation work and must be carried out in a safe manner.

2.2.1 The vehicle must be in sound working condition and effectively marked.

2.2.2 A fire extinguisher (in good working order) must be carried.

2.2.3 High explosives and detonators are not to be carried in the same receptacle.

2.2.4 No smoking is allowed.

When transporting explosives around the job site the following requirements are necessary.

2.2.5 Detonators and high explosive must be carried in separate receptacles suitably marked.

2.2.6 Any excess explosives are to be replaced in their respective magazines (in the case of AN/FO it is to be destroyed if permission for storage has not been obtained).

2.2.7 Explosives must not be stored or charged within 15 m of drilling and at all times it is advisable to remove all drilling equipment from the site before commencing charging.

### 2.3 Use

2.3.1 No smoking is allowed while handling or using explosives. This applies particularly to the AN/FO blasting agents which are susceptible to fire.

2.3.2 In safety fuse work, a suitable crimping tool must be used when attaching the detonator to the fuse. The fuse must be inspected to ensure that it is not damaged or deteriorated. Capped fuses (i.e., safety fuse plus detonator) should be coated with grease as a water-proofing agent.

Safety fuse should be ignited with a fuse igniter and a minimum length of 2 m used for primary blasting and 1.5 m for secondary blasting (or “popping”). In the event of a misfire with safety fuse, one hour must elapse before any person can enter the firing area.

2.3.3 With electric firing, the wired circuit must be tested for faulty connections, earthed or broken wires. This is done with a circuit tester. Any connections put down the hole must be covered with insulating tape to prevent current leakage.

Exploders must be tested before use to ensure that they can provide adequate current for the circuit. A fusion tester is used for the condenser type of exploder and a rheostat tester for the plunger type.

Electric firing circuits must not be wired up during thunder storms or near to radio transmitters (including two-way radio sets). In the event of a misfire with electric detonators, 15 minutes must elapse before any person can enter the firing area.

2.3.4 Detonating fuse is an explosive but is relatively safe in handling and storage. It must be cut with a sharp instrument.

2.3.5 AN/FO blasting agents are powerful explosives but are usually safe and easy to use. They are susceptible to fire or water and their use in wet holes will probably produce misfires.

2.3.6 After holes are charged, access to the area should be properly restricted and certainly no member of the public should be allowed near the holes.

2.3.7 Hard hats must be worn by all personnel associated with the blasting.

2.3.8 An acoustic warning device (e.g., a siren) should be used specifically as a warning for blasting.

2.3.9 Suitable signs should be placed where they can be readily seen by anybody approaching.

### 2.4 Misfires

Misfires are apt to be both dangerous and expensive.

They can usually be avoided by adequate testing and care but there is still the possibility of an unexplained failure. In the event of a misfire, no person shall be allowed into the firing area for :

1 hour for safety fuse firings

15 minutes for electric firings

10 minutes for detonating fuse

In the treatment of misfire :

2.4.1 No high explosive is to be removed from the misfired hole (If AN/FO is used it can be desensitised with water and then removed).

2.4.2 A misfired hole must not be redrilled. A new hole may be positioned at least 1 m from the misfired hole or for a deep hole.

2.4.3 In refiring a misfired hole a check must be made to ensure that there is adequate burden otherwise excess flyrock may result.

2.4.4 In cleaning up broken rock, after a misfire has been treated, undetonated explosives or detonators must be sought and removed if located. (Accidents have resulted from explosives passing through crushing plants).

### 2.5 Disposal

After a long period of time, most explosives tend to deteriorate (particularly in a hot, moist climate). This deterioration is noticeable on cartridges by the exudation of Nitro-Glycerine. Those explosives with a high ammonium nitrate content, tend to absorb moisture easily and this results in reduction of sensitivity and usefulness. Bulk ammonium nitrate (as used in AN/FO) is subject to degradation under the effect of heat and can be reduced to a fine powder form reducing the sensitivity to detonation.

If an explosive has deteriorated, then effective disposal must be carried out. The disposal must be complete to ensure that no high explosives or detonators can be found by the general public.

Generally explosives are destroyed by controlled burning, detonation in a safe place or in the case of ammonium nitrate, with copious quantities of water.

# 400

# GRANULAR SUB-BASES, BASES & SURFACINGS

## 401 GRANULAR/GRAVEL SUB-BASE

### 401.1 Scope

This work shall consist of laying and compacting granular material/natural gravel on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 401.2 Materials

**401.2.1** The material to be used for the work shall be natural sand, moorum, gravel, crushed stone, crushed slag, brick metal, kankar or combination thereof depending upon the grading required. The material shall be free from organic or other deleterious constituents. The granular sub-base material shall conform to any of the gradings given in **Table 400.1-A**. Where naturally occurring gravel is specified for sub-base, it shall conform to the gradings given in **Table 400.1-B**, sub-base material shall meet the physical requirements specified in **Table 400.1-C** Clause 401.2.2. The grading to be adopted for a project shall be as specified in the Contract.

**Table 400.1-A Grading for Granular Sub-base Materials**

| IS Sieve Size | Percent by Weight Passing the IS Sieve | | |
|---|---|---|---|
| | **Grading I** | **Grading II** | **Grading III** |
| 75.0 mm | 100 | – | – |
| 53.0 mm | – | 100 | – |
| 26.5 mm | 55-75 | 50-80 | 100 |
| 9.50 mm | – | – | – |
| 4.75 mm | 10-30 | 15-35 | 25-45 |
| 2.36 mm | – | – | – |
| 0.425 mm | – | – | – |
| 0.075 mm* | <15 | <15 | <15 |

* On clayey subgrades where otherwise drainage condition are encountered, the percent passing IS Sieve 0.075 mm shall not exceed 5

**Table 400.1-B Grading for Gravel Sub-base**

| IS Sieve Size | Percentage by Weight Passing IS Sieve | |
|---|---|---|
| (mm) | Grading I | Grading II |
| 53 | 100 | – |
| 37.5 | 100 | – |
| 26.5 | 75-95 | – |
| 19.0 | 80-100 | – |
| 9.5 | 40-75 | 55-80 |
| 4.75 | 30-60 | 40-60 |
| 0.425 | 15-30 | 15-30 |
| 0.075 | <15 | <15 |

The sub-base gravel shall have a minimum soaked CBR value of 20

**401.2.2** *Physical Requirements for Materials for Sub-base*

1) The material passing 425 micron sieve for all the three gradings given in Table 400.1-A and Table 400.1-B when tested according to IS:2720 (Part 5) shall satisfy the liquid limit and plasticity index characteristics specified in Table 400.1-C.

**Table 400.1-C Plasticity Characteristics of Gravel Sub-Base**

| Climate | Liquid Limit | Plasticity Index | Remarks |
|---|---|---|---|
| Areas having annual rainfall more than 1000 mm | <35 | <10 | Design traffic upto 1 million standard axles (msa) |
| Areas having annual rainfall less than 1000 mm | <40 | <15 | Design traffic upto 1 msa |
| All areas irrespective of rainfall | <25 | <6 | Design traffic more than 1 msa |

2) The Wet Aggregate Impact Value (IS:5640) shall not exceed 50.

3) The sub-base material shall have a minimum Soaked CBR value of 20 at field dry density (100 percent of maximum dry density as per IS:2720 part 7)

Where locally available moorums are used in the Granular Sub-base, it shall be ensured through adequate tests on representative samples that all the requirements set out in this Clause are satisfied.

When directed by the Engineer, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content, and any other tests for the "quality" of materials, as may be necessary.

**Note: In case the sub-base material of the requisite soaked CBR value is not available within economical leads, the sub-base material meeting the prescribed grading and other requirements with a soaked CBR value of not less than 15 can be permitted with the approval of the competent authority.*

## 401.3 Construction Operations

### 401.3.1 *Preparation of subgrade*

Immediately, prior to the laying of sub-base, the subgrade already finished to Clause 303 shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water, if necessary, and rolled with two passes of 80-100 kN smooth wheeled roller.

The sequence of construction operations shall be such that the construction of granular sub-base layer shall match the construction of the adjoining layer in the shoulders, as per Clause 407.4.1.

### 401.3.2 *Spreading and compacting*

The sub-base material of grading specified in the Contract shall be spread on the prepared subgrade with the help of suitable tractor-towed appliances in the required slope and grade, or by other means as approved by the Engineer.

When the sub-base material consists of combination of materials, mixing shall be done mechanically by the mix-in-place method. The equipment used for mix-in-place construction shall be a tractor-towed rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work. Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs

Moisture content of the loose material shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank with suitable arrangement for applying water uniformly and at controlled quantities to variable widths of surface, or by other means approved by the Engineer so that, at the time of compaction, it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS:2720 (Part 7). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical means, like tractor-towed disc harrows, rotavators, or other approved means until the layer is uniformly wet.

Immediately thereafter, rolling shall be done by an approved roller. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm, the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall or superelevation and shall commence at the edges and progress towards the crown for portions having crossfall on both sides.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked, with the help of templates and straight edge, and any high spots or depressions which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 100 percent of the maximum dry density for the material determined as per IS:2720 (Part 7). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

### 401.4 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 401.5 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Section 100.

### 401.6 Measurements for Payment

Granular sub-base shall be measured as finished work in position in cubic metres.

### 401.7 Rate

The Contract unit rate for granular sub-base shall be payment in full for carrying out the required operations including full compensation for :

i) making arrangements for traffic except for construction of diversions as directed by the Engineer;

ii) furnishing all materials to be incorporated in the work including all royalties, fees, rents where applicable and all leads and all lifts;

iii) all labour, tools, equipment and incidentals to complete the work to the Specifications;

iv) carrying out the work in part widths of road where directed; and

v) carrying out the required tests for quality control.

## 402 GRAVEL/SOIL-AGGREGATE SUB-BASE, BASE AND SURFACE COURSE

### 402.1 Scope

This work shall consist of laying and compacting well-graded gravel/ soil-aggregate material in one or more layers as sub-base, base or surface course as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 402.2 Definition

Gravel/Soil-Aggregate is a mix of stone, sand and fine-sized particles in the form of naturally occurring materials or processed to meet the specified requirements for use in construction of sub-base, base and surface courses.

### 402.3 Materials

**402.3.1** The material to be used for the work shall be natural gravel/soil-aggregate or blended with suitable aggregate fractions of stone, gravel, moorum, sand or combination of these materials depending on the grading required. The material shall be free from organic or other deleterious constituents and conform to the gradings given in Table 400.2-A and Table 400.2-B for sub-base/ base course and in Table 400.3-A and Table 400.3-B for surface course.

**402.3.2** *Physical requirements*

a) The coarse aggregate shall conform to the following requirements :

   i) Wet Aggregate Impact Value (IS:5640) shall not exceed 40 and 30 percent for use in sub-base, base and surfacing respectively.

   ii) Flakiness Index (IS:2386 (Part 1) shall not exceed 25 and 20 percent for base and surfacing respectively. This requirement shall be applicable to crushed aggregates only.

   iii) In high rainfall areas, coastal areas and where local soils are salt-infested, if the water absorption value of the coarse aggregate is greater than 2 percent, the Soundness Test shall be carried out on the material delivered to the site as per IS:2386 (Part 5).

   Loss with Sodium Sulphate, 5 cycles : 12 percent maximum

   Loss with Magnesium Sulphate, 5 cycles : 18 percent maximum

   iv) If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces.

b) Fine aggregate material passing 4.75 mm sieve shall consist of natural or crushed sand and fine mineral particles.

### 402.3.3 *Grading and plasticity reqirements for sub-base/base course*

Gravel/soil-aggregate mixtures for use in construction of sub-base/base courses shall conform to the gradings given in **Tables 400.2-A and 400.2-B**. The desired grading shall be specified.

In case a bituminous surfacing is provided, the material for use in construction of sub-base/ base shall have liquid limit and plasticity index not more than 25 and 6 respectively, when tested according to IS:2720 (Part 5). With gravel surfacing, the plasticity index shall not exceed 10.

**Table 400.2-A Grading Requirements for Sub-Base/Base Course**

| Sieve Size | Percent by Mass Passing IS Sieve Grading Designation | | |
|---|---|---|---|
| | A | B | C |
| 53 mm | 100 | | |
| 37.5 mm | 97-100 | 100 | |
| 26.5 mm | | 97-100 | 100 |
| 19 mm | 67-81 | | 97-100 |
| 9.5 mm | | 56-70 | 67-79 |
| 4.75 mm | 33-47 | 39-53 | 47-59 |
| 425 µm | 10-19 | 12-21 | 12-21 |
| 75 µm | 4-15 | 4-15 | 4-15 |

**Table 400.2-B Grading Requirements for Soil-Aggregate Mixtures for Sub-Base/Base**

| Sieve Size | Percent by Mass Passing IS Sieve Grading Designation Nominal Maximum Size | | |
|---|---|---|---|
| | 80 mm | 40mm | 20mm |
| 80 mm | 100 | | |
| 40 mm | 80-100 | 100 | |
| 20 mm | 60-80 | 80-100 | 100 |
| 10 mm | 45-65 | 55-80 | 80-100 |
| 4.75 mm | 30-50 | 40-60 | 50-75 |
| 2.36mm | - | 30-50 | 35-60 |
| 600 µm | 10-30 | 15-30 | 15-35 |
| 75 µm | 5-15 | 5-15 | 5-15 |

***Note:*** *Less than 10% should be retained between each pair of successive sieves specified for use except for the pair comprising the first two sieves*

### 402.3.4 *Grading and plasticity reqirements for surface course*

Gravel/soil-aggregate mixtures for surface course shall conform to the gradings given in **Tables 400.3-A and 400.3-B**. The desired grading shall be specified.

**Table 400.3-A Grading Requirements of Gravel for Surface Course**

| IS Sieve | Percent by Mass Passing Designated Sieve |
|---|---|
| 26.5 mm | 100 |
| 19 mm | 97-100 |
| 4.75 mm | 41-71 |
| 425 µm | 12-28 |
| 75 µm | 9-16 |

**Table 400.3-B Grading Requirements for Soil-Aggregate Mixtures for Surface Course**

| IS Sieve | Percent by Mass Passing Designated Sieve Nominal Maximum Size 10 mm |
|---|---|
| 10 mm | 100 |
| 4.75 mm | 80-100 |
| 2.36 mm | 50-80 |
| 1.18 mm | 40-65 |
| 600 µm | – |
| 300 µm | 20-40 |
| 75 µm | 10-25 |

***Note:*** *Less than 10 percent should be retained between each pair of successive sieves specified for use except for the pair comprising the first two sieves*

**Plasticity Characteristics :**

Gravel/soil-aggregate for surfacing course when tested according to IS:2720 (Part 5) shall satisfy the following requirements

| Climate | Liquid Limit (Max) | Plasticity Index |
|---|---|---|
| High rainfall areas (Annual rainfall >1500 mm) | 35 | 4-9 |
| Medium rainfall areas (Annual rainfall 750 mm-1500 mm) | 40 | 6-15 |
| Low rainfall areas (Annual rainfall <750 mm) | 55 | 15-30 |

### 402.3.5 *Strength*

The material for use in lower base course layer (layer immediately above the subbase) shall have a minimum soaked CBR value of 50 percent for use in the construction of upper base course layers a minimum soaked CBR Value of 80 percent.

***Note:*** *Exceptional cases may be relaxed suitably.*

## 402.4 Construction Operations

### 402.4.1 *Preparation of surface*

The surface of the subgrade/sub-base/base, as the case may be, to receive the Gravel/Soil-aggregate course shall be prepared to the specified lines and crossfall (camber) and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained, and if necessary, water shall be sprinkled before rolling. Any irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (levelling course) in accordance with Section 500 of these Specifications.

### 402.4.2 *Spreading and compacting*

The gravel/soil-aggregate material of grading specified in the Contract shall be spread on the prepared surface with the help of a tractor with grader attachment, for maintaining the required slope and grade during the operation or other means as approved by the Engineer. When the gravel/soil-aggregate material consists of combination of materials mentioned in Clause 402.3.1, mixing shall be done mechanically by the mix-in-place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a tractor-towed rotavator or similar approved equipment capable of mixing the materials to the desired degree. If so directed by the Engineer, trial runs with the equipment shall be carried out to establish the suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted by sprinkling additional water from a truck/ trailer mounted water bowser, suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is within 2 percent of the optimum moisture content corresponding to IS:2720 (Part 7). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means, like, tractor-towed disc harrows, rotavators until the layer is uniformly wet.

Immediately thereafter, rolling shall be done by an approved roller. If the thickness of the compacted layer does not exceed 100 mm, a smooth-wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm, the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall and superelevation and shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 100 percent of the maximum dry density for the material determined as per IS:2720 (Part 7). The surface of any layer of material on completion of compaction shall be well closed, free from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

### 402.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800. Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 402.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Section 100.

### 402.7 Measurements for Payment

Gravel/Soil-Aggregate base/surface course as the case may be, shall be measured as finished work in position in cubic metres.

### 402.8 Rate

The Contract unit rate for the Gravel/Soil-Aggregate base/surface course shall be payment in full for carrying out the required operations including full compensation for all the components listed in Clause 401.7.

## 403 LIME TREATED SOIL FOR IMPROVED SUBGRADE/SUB-BASE

### 403 General Guidelines

Lime treatment is generally adopted for silty clays and clayey soils, including Black Cotton soils. Reduction in plasticity index and development of strength in lime-soil mixes depends on the type of clay and its quantity in the soil. The lime shall have purity of not less than 70 percent by weight of quicklime (CaO) when tested in accordance with IS:1514. By way of general guidelines, the lime content requirements for different types of soils are as under:

| Soil Type | Required Lime Content |
|---|---|
| Alluvial Soils and Moorums (PI : 10-15) | 3 percent |
| Clays/BC Soils of Medium Plasticity (PI : 15-30) | 3-5 percent |
| Highly Expansive Clays (PI : over 30) | 5-6 percent |

Mix design should be worked out to decide the optimum quantity of lime to be added to obtain the required test value.

As a modifier, the quantity of lime can be determined for reducing the PI of a high PI soil to a value less than 10 and for increasing the CBR to the required value. As a stabiliser, the quantity of lime has to be worked out to attain the needed strength of the mix in terms of a 7 day Unconfined Compressive Strength (UCS) value.

It is only on the basis of mix design, carried out on representative samples of soil, as well as lime to be used, that the required quantity of lime is to be specified.

Pulverization of soil clods to the required degree and mixing of pulverized soil with lime can be accomplished by using tractor-towed implements, like, disc harrows or rotavator. A static 80 to 100 kN smooth-wheeled roller and tractor-towed water bowser are generally adequate for compaction. Curing for 7 days by covering the compacted layer with wet gunny bags, moist straw or sand periodically sprinkled with water, is an important part of the construction process.

## 403.1 Scope

This work shall consist of laying and compacting an improved subgrade/ lower sub-base of soil treated with lime on prepared subgrade in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. Lime treatment is generally effective for soils which contain a relatively high percentage of clay and silty clay.

## 403.2 Materials

### 403.2.1 *Soil*

Except when otherwise specified, the soil used for lime treatment shall be the local clayey soil having a plasticity index greater than 10.

### 403.2.2 *Lime*

Lime for lime-soil stabilisation work shall be commercial dry lime slaked at site or pre-slaked lime delivered to the site in suitable packing. Unless otherwise permitted by the Engineer, the lime shall have purity of not less than 70 percent by weight of Quick-lime (CaO) when tested in accordance with IS:1514. Lime shall be properly stored to avoid prolonged exposure to the atmosphere and consequent carbonation which would reduce its binding properties. Slaked lime supplied in airtight bags shall not be stored for more than 3 months.

### 403.2.3 *Quantity of lime in stabilised mix*

Quantity of lime to be added as percentage by weight of the dry soil shall be as specified in the Contract. The quantity of lime used shall be related to its calcium oxide content which shall be specified. Where the lime of different calcium oxide content is to be used, its quantity shall be suitably adjusted to the approval of the Engineer so that equivalent calcium oxide is incorporated in the work. The mix design shall be done to arrive at the appropriate quantity of lime to be added, having due regard to the purity of lime, the type of soil, the moisture-density relationship, and the design CBR/Unconfined Compressive Strength (UCS) value specified in the Contract. The laboratory CBR/UCS value shall be at least 1.5 times the minimum field value of CBR/UCS stipulated in the Contract.

### 403.2.4 *Water*

The water to be used for stabilisation shall be clean and free from injurious substances. Potable water shall be used.

## 403.3 Construction Operations

### 403.3.1 *Weather limitations*

Lime-soil stabilisation shall not be done when the air temperature in the shade is less than 10°C.

### 403.3.2 *Degree of pulverisation*

For lime stabilisation, the soil before addition of stabiliser, shall be pulverised using agricultural implements, like, tractor-towed disc harrows and rotavators to the extent that it passes the requirements set out in **Table 400.4**, as explained at **Annexure-400.1**.

**Table 400.4 Soil Pulverisation Requirements for Lime Stabilisation**

| IS Sieve Designation | Minimum Percent by Weight Passing the IS Sieve |
|---|---|
| 26.5 mm | 100 |
| 5.6 mm | 80 |

### 403.3.3 *Equipment for construction*

Stabilised soil sub-base shall be constructed by mix-in-place method of construction or as otherwise approved by the Engineer. Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs.

The equipment used for mix-in-place construction shall be a tractor-towed rotavator or similar approved equipment capable of pulverizing and mixing the soil with additive and water to specified degree to the full thickness of the layer being processed, and of achieving the desired degree of mixing and uniformity of the stabilised material. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for work.

The thickness of any layer to be stabilised shall be not less than 100 mm when compacted. The maximum thickness can be 200 mm, provided the plant used is accepted by the Engineer.

### 403.3.4 *Mix-in-place method of construction*

Before deploying the equipment, the soil after it is made free of undesirable vegetation or other deleterious matter shall be spread uniformly on the prepared subgrade in a quantity sufficient to achieve the desired compacted thickness of the stabilised layer. Where single-pass equipment is to be employed, the soil shall be lightly rolled as directed by the Engineer.

The equipment used shall either be of single-pass or multiple pass type. The mixers shall be equipped with an appropriate device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

With single-pass equipment, the forward speed of the machine shall be so selected in relation to the rotor speed that the required degree of mixing, pulverisation and depth of processing is obtained. In multiple pass processing, the prepared subgrade shall be pulverised to the required depth with successive passes of the equipment and the moisture content adjusted to be within prescribed limits. The blending or stabilizing material shall then be spread uniformly and mixing continued with successive passes until the required depth and uniformity of processing have been obtained. Appropriate tractor-towed equipment, approved by the Engineer, are suitable for performing various operations in the construction process, like, pulverization of soil clods by tractor-towed disc harrows and mixing of soil with stabilizer by tractor-towed rotavator.

### 403.3.5 *Construction with manual means*

Where manual mixing is permitted, the soil from borrow areas shall first be freed of all vegetation and other deleterious matter and placed on the prepared subgrade. The soil shall then be pulverised by means of crow-bars, pick axes or other means approved by the Engineer.

Water in requisite quantities may be sprinkled on the soil for aiding pulverisation. On the pulverised soil, the blending material(s) in requisite quantities shall be spread uniformly and mixed thoroughly by working with spades or other similar implements till the whole mass is uniform. After adjusting the moisture content to be within the limits mentioned later, the mixed material shall be levelled upto the required thickness so that it is ready to be rolled.

### 403.3.6 *Addition of lime*

Lime may be mixed with the prepared material either in slurry form or dry state at the option of the Contractor with the approval of the Engineer.

Dry lime shall be prevented from blowing by adding water to the lime or other suitable means selected by the Contractor, with the approval of the Engineer.

The tops of windrowed material may be flattened or slightly trenched to receive the lime. The distance to which lime may be spread upon the prepared material ahead of the mixing operation shall be determined by the Engineer.

No traffic other than the mixing equipment shall be allowed to pass over the spread lime until after completion of mixing.

Mixing or remixing operations, regardless of equipment used, shall continue until the material is free of any white streaks or pockets of lime and the mixture is uniform.

Non-uniformity of colour reaction, when the treated material is tested with the standard phenolphthalein alcohol indicator, shall be considered evidence of inadequate mixing.

### **403.3.7** *Moisture content for compaction*

The moisture content at compaction determined as per IS:2720 (Part 2) shall be within 2 percent of the optimum moisture content corresponding to IS:2720 (Part 7).

### **403.3.8** *Rolling*

Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out with 80-100 kN static weight smooth-wheeled roller or other roller approved by the Engineer. Rolling shall begin at the edges and progress towards the centre on straight portions. On superelevated curves, the rolling shall proceed from the inner to the outer edge. Compaction shall continue until the density achieved is at least 100 percent of the maximum dry density of the material as per IS:2720 (Part 7). The suitability of a particular compaction equipment and number of passes required may be verified on a test strip. Ideally, not more than 60 minutes shall elapse between the start of moist mixing and start of compaction process. Care shall be taken to see that compaction is completed within 3 hours of mixing or such shorter period as may be necessary during dry weather.

During rolling, it shall be ensured that the roller does not bear directly on hardened or partially hardened treated material previously laid other than what may be necessary for achieving the specified compaction at the joint. The final surface shall be well closed, free from movement under compaction planes, ridges, cracks or loose material. All loose or segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

### **403.3.9** *Curing*

Curing of the compacted layer shall be carried out for a minimum period of 7 days by spreading moist straw/wet gunny bags or sand and sprinkling water periodically. Curing by ponding of water shall not be permitted to avoid leaching of lime. After the curing period is over, subsequent pavement layers shall be laid as early as possible to prevent the surface from drying out. No traffic shall be allowed to ply during the curing period, unless permitted by the Engineer.

## **403.4 Surface Finish and Quality Control of Work**

The surface finish of construction shall conform to the requirements of Section 1800.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 403.5 Strength

When lime is used for improving the subgrade, the soil-lime mix shall be tested for its CBR value. When lime stabilised soil is used in a sub-base, it shall be tested for unconfined compressive strength (UCS) at 7 days. In case of variation from the design CBR/UCS, in-situ value being lower, the pavement design shall be reviewed based on the actual CBR/UCS values. The extra pavement thickness needed on account of lower CBR/UCS value shall be constructed by the Contractor at his own cost.

### 403.6 Arrangements of Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Section 100.

### 403.7 Measurements for Payment

Stabilised soil sub-base shall be measured as finished work in position in cubic metres.

### 403.8 Rate

The Contract unit rate for lime stabilised soil sub-base shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7.

## 404 CEMENT STABILISED SUB-BASE/BASE

### 404 General Guidelines

Stabilisation with cement is resorted to for soils and other locally available materials which do not respond to lime treatment and where comparatively higher and faster development of strength and durability characteristics are needed, especially for waterlogged and high rainfall areas. Granular and sandy soils are most suitable for cement stabilisation. By way of broad guidelines, the requirements of cement content for different soil types are as under:

| **Soil Type** | **Required Cement Content** |
|---|---|
| Sands/Sandy Soils/Soil-Gravels | 3-5 percent |
| Silts/Silty Clays of Low PI (<15) | 4-8 percent |
| Clays/Black Cotton Soils | 8-15 percent |

For heavy clays/black cotton soils (PI more than 30), the clay is treated with lime in the first stage to reduce plasticity and to facilitate pulverization. In the second stage, the resulting soil is stabilised with cement.

Mix Design should be worked out to specify the amount of cement to be added to obtain the required strength in terms of 7-day Unconfined Compressive Strength (UCS) and/or durability test under alternate wet-dry conditions. Pulverisation of soil clods, mixing of pulverised soil with the required amount of cement, compaction and curing of the compacted layer are important construction operations, as in the construction of lime treated soil subbase.

### 404.1 Scope

This work shall consist of laying and compacting a sub-base/base course of soil treated with cement on prepared subgrade/sub-base, in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 404.2 Materials

#### 404.2.1 *Material to be stabilised*

The material used for cement treatment shall be soil including sand and gravel, laterite, kankar, brick aggregate, crushed rock, metallic slag or flyash, pond ash or any locally available materials/industry wastes or any combination of these as approved by the Engineer. For use in a sub-base course, the material shall have a grading shown in **Table 400.5**, and a uniformity coefficient (Cu)* not less than 5, capable of producing a well closed surface finish. For use in a base course, the material shall be sufficiently well graded to ensure a well-closed surface finish and have a grading within the range given in **Table 400.5**. If the material passing 425 micron sieve is plastic, it shall have a liquid limit not greater than 45 percent and a plasticity index not greater than 20 percent determined in accordance with IS:2720 (Part 5).

#### 404.2.2 *Cement*

Cement for cement stabilisation shall comply with the requirements of IS:269, 455 or 1489.

#### 404.2.3 *Lime*

If needed for pre-treatment of highly clayey soils (PI more than 30), Clause 403.2.2 shall apply.

**Table 400.5 Grading Limits of Material for Stabilisation with Cement**

| **IS Sieve** | **Percent by Weight Passing Within the Range** |
|---|---|
| | **Sub-base / Base** |
| 53.0 mm | 100 |
| 37.5 mm | 95-100 |
| 19.0 mm | 45-100 |
| 9.5 mm | 35-100 |
| 4.75 mm | 25-100 |
| 600 micron | 8-65 |
| 300 micron | 5-40 |
| 75 micron | 0-10 |

**404.2.4** *Quantity of cement in stabilised mix*

The quantity of cement to be added as percent by weight of the dry soil shall be specified in the Contract. Also, if lime is used as pre-treatment for highly clayey soils, the quantity as percent by weight of dry soil shall be specified in the Contract. The mix design shall be done on the basis of 7 day unconfined compressive strength.

**404.2.5** *Water*

Clause 403.2.4 shall apply.

**404.2.6** *Minimum compressive strength*

Unless otherwise specified, the mix shall be designed for a minimum laboratory 7 day compressive strength of 2.76 MPa for use in base course, and 1.7 MPa for sub-base.

### 404.3 Construction Operations

**404.3.1** *Weather limitations*

Stabilisation shall not be done when the air temperature in the shade is less than 10°C.

**404.3.2** *Degree of pulverisation*

For stabilisation, the soil before addition of stabiliser, shall be pulverised, where necessary, to the extent that it passes the requirements as set out in **Table 400.6**, explained at Annexure-400.1.

**Table 400.6 Soil Pulverisation Requirements for Cement Stabilisation**

| IS Sieve Designation | Minimum percent by Weight Passing the IS Sieve |
|---|---|
| 26.5 mm | 100 |
| 5.6 mm | 80 |

**404.3.3** Clauses 403.3.3 to 403.3.5 shall apply as regards spreading and mixing the stabiliser except that cement or lime plus cement as the case may be, shall be used as the stabilizing materials.

**404.3.4** *Moisture content for compaction*

The moisture content at compaction determined as per IS:2720 (Part 2) shall be within 2 percent of the optimum moisture content corresponding to IS:2720 (Part 7).

**404.3.5** *Rolling*

Clause 403.3.8 shall apply except that care shall be taken to see that the compaction of cement stabilised materials is completed within two hours of its mixing or such shorter period as may be found necessary in dry weather.

**404.3.6** *Curing*

Clause 403.3.9 shall apply.

### 404.4 Surface Finish and Quality Control of Works

The surface finish of construction shall conform to the requirements of Section 1800.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 404.5 Strength

Cement treated soil sub-base/base shall be tested for the unconfined compressive strength value at 7 days, actually obtained in situ. In case of variation from the design UCS, in-situ value being on lower side, prior to proceeding with laying of base/surface course on it, the pavement design shall be reviewed for the actual UCS value. The extra pavement thickness needed on account of lower UCS shall be constructed by the Contractor at his own cost.

### 404.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Section 100.

### 404.7 Measurements for Payment

The cement treated soil sub-base/base shall be measured as finished work in position in cubic metres.

### 404.8 Rate

The Contract unit rate for cement treated soil sub-base/base with pre-treatment with lime if required shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7.

## 405 WATER BOUND MACADAM SUB-BASE/BASE/SURFACING

### 405.1 Scope

**405.1.1** This work shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonding together with screening, binding material where necessary, and water laid on a properly prepared subgrade/sub-base/base or existing pavement, as the case may be and finished in accordance with the requirements of these Specifications and in close conformity with the lines, grades, cross-sections and thickness as per approved plans or as directed by the Engineer.

### 405.2 Materials

#### 405.2.1 *Coarse aggregates*

Coarse aggregates shall be either crushed or broken stone, crushed slag, overburnt (Jhama) brick aggregates or any other naturally occurring aggregates, such as, kankar and laterite of suitable quality. Materials obtained from rocks, such as, Phyllites, Shales or Slates, etc. shall not be permitted in WBM construction. Materials other than crushed or broken stone and crushed slag shall be used in sub-base courses only. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in **Table 400.7**. The type and size range of the aggregate shall be specified in the Contract or shall be as specified by the Engineer. If the water absorption value of the coarse aggregate is greater than 2 percent, the Soundness test shall be carried out on the material delivered to site as per IS:2386 (Part 5).

**405.2.2** Aggregates, like, brick bats, kankar, laterite, etc. which get softened in presence of water shall be tested for Aggregate Impact Value under wet conditions in accordance with IS:5640.

**Table 400.7 Physical Requirements of Coarse Aggregates for Water Bound Macadam for Sub-base/Base/Surfacing Courses**

| Test | Sub-base | Base | Surfacing |
|---|---|---|---|
| Aggregate Impact Value<br>(IS:2386 Part 4 or IS:5640) | Less than 50 | Less than 40 | Less than 30 |
| Flakiness Index<br>(IS:2386 Part 1) | Less than 30 | Less than 25 | Less than 20 |
| Soundness Test<br>(IS:2386 Part 1) | | | |
| – Loss with Sodium Sulphate | Less than 12% | Less than 12% | Less than 12% |
| – Loss with Magnesium Sulphate | Less than 18% | Less than 18% | Less than 18% |

**405.2.3** The requirement of flakiness Index shall be enforced only in the case of crushed or broken stone and crushed slag.

**405.2.4** *Crushed or broken stone*

The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other deleterious material.

**405.2.5** *Crushed slag*

Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other deleterious materials. The weight of crushed slag shall not be less than 11.2 kN per cum. It shall also comply with the following requirements:

i) Chemical stability: Steel slag shall comply with the requirements of BS: 1047

ii) Water absorption: Max. 10 percent

**405.2.6** *Overburnt (Jhama) brick aggregates*

Jhama brick aggregates shall be made from overburnt bricks or brick ballast and be free from dust and other objectionable and deleterious materials.

### 405.2.7 *Grading requirement of coarse aggregates*

The coarse aggregates shall conform to one of the Gradings given in **Table 400.8** as specified. The use of Grading No.1 shall be restricted to sub-base courses only.

**Table 400.8 Grading Requirements of Course Aggregates***

| | Size Range | IS Sieve Number | Passing Percent by Weight |
|---|---|---|---|
| 1) | 90 mm to 45 mm | 125 mm | 100 |
| | | 90 mm | 90-100 |
| | | 63 mm | 25-60 |
| | | 45 mm | 0-15 |
| | | 22.4 mm | 0-5 |
| 2) | 63 mm to 45 mm | 75 mm | 100 |
| | | 63 mm | 90-100 |
| | | 53 mm | 25-75 |
| | | 45 mm | 0-15 |
| | | 22.4 mm | 0-5 |
| 3) | 53 mm to 22.4 mm | 63 mm | 100 |
| | | 53 mm | 95-100 |
| | | 45 mm | 65-90 |
| | | 22.4 mm | 0-10 |
| | | 11.2 mm | 0-5 |

* (i) The gradings for the aggregate are to be met with before using them for WBM construction. After rolling and compaction of WBM layer, the grading may vary from the specified values.

(ii) Engineer may allow ± 5 percent variation from the specified upper and lower limits excluding the first and the last sieve in the gradings.

### 405.2.8 *Screenings*

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where economic considerations so warrant, predominantly non-plastic material (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent. The screenings shall not contain any of the undesirable constituents listed in Clause 301.2.3 which would render it unsuitable as a fill material.

Screenings shall conform to the grading set forth in **Table 400.9**. The details of quantity of screenings required for various grades of stone aggregates are given in **Table 400.10**. The

Table also gives the quantities of materials (loose) required for 10 m$^2$ for sub-base/base/surfacing compacted thickness of 100/75 mm.

**Table 400.9 Grading for Screenings**

| Grading Classification | Size of Screenings | IS Sieve Designation | Percent by Weight Passing the IS Sieve |
|---|---|---|---|
| A | 13.2 mm | 13.2 mm | 100 |
| | | 11.2 mm | 95-100 |
| | | 5.6 mm | 15-35 |
| | | 180 micron | 0-10 |
| B | 11.2 mm | 11.2 mm | 100 |
| | | 9.5 mm | 80-100 |
| | | 5.6mm | 50-70 |
| | | 180 micron | 15-35 |

The use of screenings shall be omitted in the case of soft aggregates, such as, brick metal, kankar, laterite, etc. as they are likely to get crushed to a certain extent under rollers.

**Table 400.10 Approximate Quantities of Coarse Aggregates and Screenings Required for 100/75mm Compacted Thickness of Water Bound Macadam (WBM) Sub-base/Base/surfacing Course for 10 m$^2$ Area**

| | | | | Stone Screenings * | | Crushable Screenings such as moorum/gravel | |
|---|---|---|---|---|---|---|---|
| Classification | Size Range | Compacted Thickness | Loose Quantity | Grading Classification & Size | For WBM Sub-base/Base Course (Loose Quantity) | Properties | Loose Quantity |
| | m$^2$ | mm | m$^3$ | | m$^3$ | | m$^3$ |
| Grading 1 | 90 to 45 | 100 | 1.21 to 1.43 | Type A 13.2 | 0.27 to 0.30 | LL<20; PI<6 Percent 0.075 passing mm <10 | 0.30 to 0.32 |
| Grading 2 | 63 to 45 | 75 | 0.91 to 1.07 | Type A 13.2 | 0.12 to 0.15 | -do- | 0.22 to 0.24 |
| Grading 2 | 63 to 45 | 75 | 0.91 to 1.07 | Type B 11.2 | 0.20 to 0.22 | -do- | -do- |
| Grading 3 | 53 to 22.4 | 75 | 0.91 to 1.07 | Type B 11.2 | 0.18 to 0.21 | -do- | -do- |

*Quantity of stone screenings for surfacing course will be about 80% of the quantity for sub-base/base course.

### 405.2.9 *Binding material*

Binding material to be used for water bound macadam as a filler material meant for preventing ravelling, shall comprise of a suitable material approved by the Engineer having a Plasticity

Index (PI) value of less than 6 for sub-base/base course and 4 to 10 for surfacing course as determined in accordance with IS:2720 (Part 5).

The quantity of binding material where it is to be used, will depend on the type of screenings and function of WBM. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 $m^3/10\ m^2$ for sub-base/base course and 0.10-0.15 $m^3/10\ m^2$ for surfacing course. For 100 mm compacted thickness of WBM (Grading 1) for sub-base the quantity needed will be 0.08-0.10 $m^3/10\ m^2$.

The above mentioned quantities should be taken as a guide only, for estimation of quantities for construction, etc.

Application of binding materials may not be necessary when the screenings used are of crushable type.

## 405.3 Construction Operations

### 405.3.1 *Preparation of base*

The surface of the subgrade/sub-base/base to receive the water bound macadam course shall be prepared to the specified lines, grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained if necessary by sprinkling water.

Where the WBM is to be laid on an existing metalled road, any irregularities, depressions, pot holes shall be repaired and the existing surface rectified to the required grade and camber with suitable material before spreading the coarse aggregate for WBM.

Laying water bound macadam course over an existing bituminous layer shall be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. The existing thin bituminous wearing course shall be scarified completely before laying the WBM layer.

### 405.3.2 *Inverted choke*

Where the WBM layer is to be laid directly over the subgrade and the subgrade soil is fine-grained, it is advisable to lay 100 mm intervening layer of screening or coarse sand on top of the fine-grained soil.

### 405.3.3 *Provision of lateral confinement of aggregates*

While constructing water bound macadam, arrangement shall be made for the lateral confinement of the aggregates. This shall be done by building adjoining shoulders along with water bound macadam layers and following the sequence of operations described in Clause 407.4.1.

The practice of constructing WBM in a trench section excavated in the finished formation shall not be followed. Where the WBM course is to be constructed in narrow widths for widening of an existing pavement, the existing shoulders shall be excavated to their full depth and width upto the subgade level except where widening specifications envisage laying of a stabilized sub-base using in-situ operations in which case the sholders shall be removed upto the sub-base level.

### 405.3.4 *Spreading coarse aggregates*

The coarse aggregates shall be spread uniformly and evenly upon the prepared subgrade/ sub-base/base to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than 100 mm for Grading 1 and 75 mm for Grading 2 and 3, as specified in Clause 405.2.5. Aggregates placed at locations which are inaccessible to the spreading equipment, may be spread in one or more layers by any approved means so as to achieve the specified results.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. No segregation of large or fine aggregates shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface as per approved drawings.

The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operations.

### 405.3.5 *Rolling*

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of 80 to 100 kN static weight.

Except on superelevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inward parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. However, where screenings are not to be applied, as in the case of crushed aggregates, like, brick metal, laterite and kankar, compaction shall be continued until the aggregates are thoroughly keyed. During rolling, slight sprinkling of water may be done, if necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or sub-base course.

The rolled surface shall be checked transversely with templates and longitudinally with 3m straight edge. Any irregularities, exceeding the maximum permissible limits, shall be corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to desired camber and grade. In no case shall the use of screenings be permitted to make up depressions.

Material which gets crushed excessively during compaction or becomes segregated shall be removed and replaced with suitable aggregates.

It shall be ensured that shoulders are built up simultaneously along with water bound macadam courses, in accordance with the procedure given in Clause 407.4.1.

### 405.3.6 *Application of screenings*

After the coarse aggregate has been rolled to Clause 405.3.5, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

### 405.3.7 *Sprinkling of water and grouting*

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operation shall be continued, with additional screenings applied as necessary until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or subgrade does not get damaged due to the addition of excessive quantities of water during construction.

In case of lime treated soil sub-base, construction of water bound macadam on top of it shall be done after the sub-base has been cured and has attained adequate strength, as directed by the Engineer.

### 405.3.8 *Application of binding material*

After the application of screenings in accordance with Clauses 405.3.6 and 405.3.7, the binding material where it is required to be used (Clause 405.2.9), shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

### 405.3.9 *Setting and drying*

After the final compaction of water bound macadam course, the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course, if in his opinion it would cause excessive damage to the surface.

The compacted water bound macadam course should be allowed to completely dry and set before the next pavement course is laid over it.

## 405.4 Surface Finish and Quality Control of Work

**405.4.1** The surface finish of construction shall conform to the requirements of Section 1800.

**405.4.2** Control on the quality of material and works shall be exercised by the Engineer in accordance with Section 1800.

**405.4.3** The water bound macadam work shall not be carried out when the atmospheric temperature is less than 10°C in the shade.

### 405.4.4 *Reconstruction of defective macadam*

The finished surface of water bound macadam shall conform to the tolerance of surface regularity as prescribed in Section 1800. However, where the surface irregularity of the course exceeds the tolerances or where the course is otherwise defective due to subgrade soil mixing with the aggregates, the course to its full thickness shall be scarified over the affected area, reshaped with added material or removed and replaced with fresh material as applicable and recompacted. The area treated shall not be less than 10 sqm. In no case shall depressions be filled up with screenings or binding material.

## 405.5 Arrangement for Traffic

During the period of construction, the arrangements for traffic shall be provided and maintained as per Section 100.

## 405.6 Measurements for Payment

Water bound macadam shall be measured as finished work in position in cubic metres.

## 405.7 Rate

The Contract unit rate for water bound macadam sub-base/base/surfacing course shall be payable in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 including arrangements of water used in the work as approved by the Engineer.

## 406 WET MIX MACADAM BASE

### 406.1 Scope

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-base/base of existing pavement as the case may be, in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted thickness of a single layer of the base course may be upto 200 mm with the approval of the Engineer.

### 406.2 Materials

### 406.2.1 *Aggregates*

### *406.2.1.1 Physical requirements*

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravels/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in **Table 400.11**.

**Table 400.11 Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Base Course**

| Test | Test Method | Requirements |
|---|---|---|
| 1) Aggregate Impact Value | IS:2386 (Part 4) or IS:5640 | 40 percent (Max) |
| 2) Flakiness Index | IS:2386 (Part 1) | 25 percent (Max) |

If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part 5).

### *406.2.1.2 Grading requirements*

The aggregates shall conform to the grading given in **Table 400.12**.

**Table 400.12 Grading Requirements of Aggregates for Wet Mix Macadam**

| IS Sieve Designation | Percent by Weight Passing the IS Sieve |
|---|---|
| 53.00 mm | 100 |
| 45.00 mm | 95-100 |
| 26.50 mm | – |
| 22.40 mm | 60-80 |
| 11.20 mm | 40-60 |
| 4.75 mm | 25-40 |
| 2.36 mm | 15-30 |
| 600 micron | 8-22 |
| 75 micron | 0-5 |

Materials finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

### 406.3 Construction Operations

#### 406.3.1 *Preparation of base*

Clause 405.3.1 shall apply.

#### 406.3.2 *Provision of lateral confinement of aggregates*

Clause 405.3.3 shall apply.

#### 406.3.3 *Preparation of mix*

Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/ positive mixing arrangement like pugmil or pan type mixer of concrete batching plant. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part 7) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix shall not vary from the optimum value by more than agreed limits. The mixed material shall be uniformly wet and no segregation shall be permitted.

### 406.3.4 *Spreading of mix*

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-base in required quantities. In no case shall these be dumped in heaps, directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix shall be spread using mechanical means like paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used. The motor grader shall be capable of spreading the material uniformly all over the surface.

The paver finisher shall be self-propelled, having the following features:

i) Loading hoppers and suitable distribution mechanism

ii) The screed shall have tamping and vibrating arrangement for initial compaction of the layer.

iii) The paver shall be equipped with necessary control mechanism to maintain layer thickness and profile.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of large and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

### 406.3.5 *Compaction*

After the mix has been laid to the required thickness, grade and camber, the same shall be uniformly compacted, to the full depth with suitable roller.

If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm thickness, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity roller. The speed of the roller shall not exceed 5 km per hour.

In portions having unidirectional cross fall/superelevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre, parallel to the centre line of the road uniformly overlapping each of the preceding tracks by at lest one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/ or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or subgrade. If irregularities develop during rolling which exceed 12 mm when tested with 3 m straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case should the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 100 percent of the maximum dry density for the material as per IS:2720 (Part 7).

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

#### **406.3.6** *Setting and drying*

After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

### 406.4 Opening to Traffic

No vehicular traffic shall be allowed on the finished wet mix macadam surface till it has dried and the wearing course laid.

### 406.5 Surface Finish and Quality Control of Work

#### **406.5.1** *Surface evenness*

The surface finish of construction shall conform to the requirements of Section 1800.

#### **406.5.2** *Quality control*

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 406.6 Rectification of Surface Irregularity

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances, the full thickness of the layer shall be scarified over the affected area, reshaped with added premixed material or removed and replaced with fresh premixed material as applicable and recompacted in accordance with Clause 406.3. The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

### 406.7 Arrangement for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained as per Section 100.

### 406.8 Measurements for Payment

Wet mix macadam shall be measured as finished work in position in cubic metres.

### 406.9 Rate

The Contract unit rate for wet mix macadam shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7.

## 407 SHOULDER CONSTRUCTION

### 407.1 Scope

The work shall consist of constructing shoulder (hard/earthen with brick or stone block edging) on either side of the pavement, in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 407.2 Materials

Shoulder on either side of the road may be of selected earth/granular material conforming to the requirements of Section 300 and Clause 401. Selected earth shoulder where specified shall conform to the requirements of Section 300 and shall be less than 10 percent.

Where hard shoulders are not provided, the pavement shall be provided with brick/stone block edgings as shown in the drawings. The bricks shall conform to Section 600 of these Specifications. Stone blocks shall conform to Section 700 of these Specifications and shall be of size 225 mm x 110 mm x 75 mm.

### 407.3 Size of Shoulders

Shoulder (earthen/hard) dimensions shall be as shown on the drawings or as directed by the Engineer.

### 407.4 Construction Operations

**407.4.1** The sequence of operations shall be such that the construction of shoulders is done in layers, each matching the thickness of adjoining pavement layer. Only after a layer of pavement and corresponding layers in hard and earthen shoulder portion have been laid and compacted, the construction of next layer of pavement and shoulder shall be taken up.

Where the materials in adjacent layers are different, these shall be laid together and the pavement layer shall be compacted first. The adjacent layers having same material shall be laid and compacted together.

In all cases where hard shoulders have to be provided along side of existing carriageway, the existing shoulders shall be excavated in full width and to the required depth as per Section 300. Under no circumstances, box cutting shall be done for construction of shoulders.

Compaction requirement of earthen/hard shoulder shall be at least 100 percent of Maximum Dry Density as per IS:2720 (Part 7).

During all stages of shoulder (earthen) construction, the required crossfall shall be maintained to drain off surface water.

Regardless of the method of laying, all shoulder construction material shall be placed directly on the under-layers of shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed, without damage to the pavement, and the area so affected thoroughly cleaned.

### 407.4.2 *Brick/stone block edging*

The bricks/stone blocks shall be laid on edge, with the length parallel to the transverse direction of the road. These shall be laid on a bed of 25 mm sand, set carefully, rolled into position by a light roller and made flush with the finished level of the pavement.

### 407.5 Surface Finish and Quality Control of Works

The surface finish of construction shall conform to the requirements of Section 1800. Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 407.6 Measurements for Payment

Shoulder (hard/earthen) construction shall be measured as finished work in position as below:

i) For excavation in cubic metres
ii) For earthwork/granular fill in cubic metres
iii) For brick/stone block edging in running metre.

### 407.7 Rate

The Contract unit rate for shoulder (hard/earthen with brick or stone block edging) shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 as applicable. The rate for brick/stone block edging shall include the cost of sand cushion.

## 408 LOCAL MATERIALS FOR ROAD CONSTRUCTION

### 408.1 Scope

This Specification covers the use of local materials as such or after their processing, for road construction in areas where quality materials are not available within economical leads.

It includes the laying and compacting of such low cost materials in one or more layers as subbase, base or surface course as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 408.2 Definition

Low cost materials for road construction are the locally available soils and low-grade/marginal aggregates with requisite engineering properties which are both suitable and economical for incorporation (as such or after processing, as may be needed) in the pavement crust of low volume roads, in lieu of the conventionally used high quality road materials.

### 408.3 Materials

**408.3.1** The quality and quantity of various sources of different types of soils and low-grade/marginal aggregates locally available, shall be established through scientifically carried out soils and materials surveys as per the procedures laid down in IRC:SP:20.

**408.3.2** Material characterization and usage : The manner of using the locally available low-grade/marginal aggregates shall be as per **Table 400.13**. The different types of soil stabilisation techniques appropriate for different types of locally available soils shall be as given in **Table 400.14**.

**Table 400.13 Manner of Using Low-Grade Aggregates in Rural Road Pavements**

| S. No | State of Occurrence of Materials | Manner Using in Pavement Crust | Test/Quality Requirement |
|---|---|---|---|
| 1) | In block or large discrete particles such as Kankar Laterite, Dhandla, etc. | As water bound macadam without screening/filler<br>After breaking the material into required sizes | Wet Aggregate Impact Value (IS:5640) not to exceed 50, 40, and 30 when used in sub-base, base and surfacing respectively.<br>For constructing lower base course in case of roads carrying design traffic upto 60,000 standard axles (Traffic T1 orT2 Category). Wet AIV value can be increased upto 50 percent and flakiness index upto 30 percent. |
| 2) | Graded form without appreciable amount of soil, such as naturally occurring gravels. | Directly as a granular layer for sub-base/base or surfacing | Plasticity characteristics to meet requirements as specified for GSB materials based on annual rainfall and traffic conditions. Evaluated for strength by soaked CBR. |

| | | | |
|---|---|---|---|
| 3) | As discrete particles mixed with appreciable amount of soil such as soil-gravel mixtures, quarry wastes, etc. | Directly as soil-gravel for sub-base, for base or surfacing. | The material shall be well graded and the PI restricted as Sl.No.2. Evaluated for strength by soaked CBR. |

**Table 400.14 Requirements of Soil Stabilisation Techniques**

| Sl. No. | Soil Stabilisation Technique | Applicability to Different Soil Types |
|---|---|---|
| 1) | Mechanical Stabilisation | Sands, moorums/gravels having missing fractions and clayey soils. |
| 2) | Lime Stabilisation | Medium and heavy clays having PI > 10 and containing at least 15 percent of material finer than 425 micron. A soil whose 7 day unconfined compressive strength increases by at least 0.3 MN/m$^2$ with lime treatment is suitable. |
| 3) | Cement Stabilisation | Granular soils with organic content not greater than 2 percent or deleterious salts (sulphates and carbonates) not greater than 0.2 percent are suitable. Plasticity Product (product of PI and percent passing 425 micron sieve) should be less than 250 and uniformity coefficient >5. |
| 4) | Lime-Flyash Stabilisation | Soils of medium plasticity (PI 5-20) and clayey soils not reactive to lime. |
| 5) | Two-Stage (Lime-Cement) Stabilisation | Heavy clays with PI > 30. |

### 408.4 Construction Operations

**408.4.1** *Use of low-grade aggregates*

i) As water bound macadam : Clause 405.3 shall apply
ii) As granular layer for sub-base : Clause 401.4 shall apply
iii) As soil-gravel mix for sub-base, base or surfacing : Clause 402.4 shall apply

**408.4.2** *Use of stabilised soil*

i) Mechanical Stabilisation : Clause 401.4 shall apply
ii) Lime Stabilisation : Clause 403.3 shall apply
iii) Cement Stabilisation : Clause 404.3 shall apply
iv) Lime-Flyash Stabilisation : Clause 409.5 shall apply
v) Two-stage (Lime-Cement) Stabilisation : Clause 404.3 shall apply

### 408.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 408.6 Strength

When lime stabilisation is adopted, Clause 403.5 shall apply. In case of Cement, Two-stage (Lime-Cement) and Lime-Flyash, Clauses 404.5 and 409.9 shall apply.

### 408.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Section 100.

### 408.8 Measurements for Payment

The sub-base/base/surface course, as the case may be, constructed with local materials shall be measured as finished work in position in cubic metres.

### 408.9 Rate

The Contract unit rate for sub-base/base/surface course constructed with local materials shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7.

## 409 LIME-FLYASH STABILISED SOIL SUB-BASE

### 409.1 Scope

This work shall consist of laying and compacting Lime-flyash stabilised soil sub-base on prepared subgrade in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 409.2 Definition

Lime-flyash stabilised soil is a mixture of soil and flyash, when stabilised with lime.

### 409.3 Materials

#### 409.3.1 *Flyash*

Flyash may be either from anthracitic coal or lignitic coal. The Flyash to be used in lime-flyash stabilisation of soil shall conform to the requirements given in **Tables 400.15 and 400.16**.

Table 400.15 Chemical Requirements for Flyash as a Pozzolana

| Sl. No. | Characteristics | Requirements for Flyash | | |
|---|---|---|---|---|
| | | Anthracitic Flyash | Lignitic Flyash | Method of Test |
| 1) | $SiO_2+Al_2O_3+Fe_2O_3$ in percent by mass, Min | 70 | 50 | IS:1727 |
| 2) | $SiO_2$ in percent by mass, Min | 35 | 25 | IS:1727 |
| 3) | MgO in percent by mass, Max | 5.0 | 5.0 | IS:1727 |
| 4) | $SO_3$ in percent by mass, Max | 2.75 | 3.5 | IS:1727 |
| 5) | Available alkalies as $Na_2O$ in percent by mass, Max | 1.5 | 1.5 | IS:4032 |
| 6) | Total chlorides in percent by mass, Max | 0.05 | 0.05 | IS:1727 |
| 7) | Loss on ignition in percent by mass, Max | 5.0 | 5.0 | IS:1727 |

Table 400.16 Physical Requirements for Flyash as a Pozzolana

| Sl.No. | Characteristics | Requirement |
|---|---|---|
| 1) | Fineness – specific surface in $m^2/kg$ by Blaine's permeability test, Min | 250 |
| 2) | Particles retained on 45 micron IS sieve, Max | 40 |
| 3) | Lime reactivity in $N/mm^2$, Min | 3.5 |
| 4) | Soundness by autoclave test-expansion of specimen in percent, max | 0.8 |
| 5) | Soundness by Lechatelier method – expansion in mm, Max | 10 |

**409.3.2** *Lime*

The lime to be used for lime-flyash soil stabilisation shall be quick lime, which has been pre-slaked at site and shall be used within 7 days. Slaked lime supplied in airtight bags shall not be stored for more than 3 months. The lime shall have a purity of not less 70 percent by weight of CaO, when tested as per IS:1514.

**409.3.3** *Soil*

The soil shall have a plasticity index between 4 and 20; however, this technique may also be applied to soil with plasticity index more than 20, provided strength tests on lime-flyash soil mixes show favourable results. The ideal proportion of particles smaller than 425 micron sieve shall be between 15 and 25 percent by dry weight of the soil-lime-flyash mixture.

**409.3.4** *Water*

Water for mixing and curing shall be clean and free from injurious salts, organic matter and other deleterious matter. Potable water shall be considered satisfactory.

### 409.4 Mix Proportion

The mix proportion shall be designed to obtain minimum unconfined compressive strength of 1.5 MPa after 28 days of moist curing. The component of soil in the lime-flyash-soil mix can be omitted, provided the specified minimum strength requirement is achieved.

### 409.5 Construction Operations

### 409.5.1 *Preparation of subgrade*

The subgrade over which the lime-flyash soil layer is to be laid shall be shaped to the desired profile and checked for line, grade and cross-section. All irregularities beyond the permitted tolerance shall be corrected and the surface prepared by light sprinkling with water and rolling with 80 to 100 kN static weight smooth-wheeled roller. Soft and yielding spots, ruts etc if present shall be rectified and backfilled with suitable material and rolled until firm.

### 409.5.2 *Weather limitations*

Lime-flyash soil stabilisation shall not be done when air temperature in the shade is less than 10°C.

### 409.5.3 *Mixing method*

Lime and flyash shall preferably be mixed by weigh batching; however, when unavoidable, volume batching can be resorted to. The mix-in-place method shall be adopted, which requires distribution of flyash and lime evenly over the work area, subsequent addition of moisture and mixing with a mobile mixing plant.

If permitted by the Engineer, manual mixing my be adopted. Soil shall be free from all vegetation and other deleterious matter and pulverised to conform to the requirements given in **Table 400.17**, as explained at **Annexure-400.1**.

**Table 400.17 Soil Pulverization Requirements for Lime-Flyash Stabilisation**

| IS Sieve | Percent weight of Soil Passing IS Sieve |
|---|---|
| 26.5 mm | 100 |
| 5.6 mm | 80 |

### 409.5.4 *Spreading and moisture control*

First, the soil shall be spread uniformly on the prepared subgrade, the thickness of uncompacted layer being about 25 to 35 percent more than the specified compacted thickness, determined through field trials. Lime and flyash shall be spread ahead of mixing, taking care to prevent raising of dust. A tractor-towed rotavator or any similar equipment shall be used for mixing. Mixing shall be continued with successive passes until the required uniformity of mixing has been obtained. The specified moisture content prior to compaction shall be the optimum moisture content (OMC)+2 percent, to compensate for the loss of moisture during spreading. If it is necessary to adjust the moisture content of the mix, water shall be added uniformly and in a controlled manner using a Water Bowser fitted with a sprinkler. Water shall then be uniformly mixed, with the soil-lime-flyash mix using tractor-towed disc harrows or similar equipment.

Where manual mixing is adopted, soil free from organic matter, is scarified or brought from the identified borrow areas and pulverised using crow bars, pickaxes etc., to meet the specifications given in **Table 400.17**. Water in requisite quantities may be sprinkled on soil to aid pulverisation. On the pulverised soil, lime and flyash shall be spread uniformly and mixed thoroughly by working with spades or other implements to get a uniform mix. After adjusting the moisture content to be within the limits specified, the mixed material shall be spread upto the required thickness.

### **409.5.5** *Compaction*

Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out with 80-100 kN static weight smooth-wheeled roller or other roller approved by the Engineer. Rolling shall begin at the edges and progress towards the centre on straight portions. On superelevated curves the rolling shall proceed from the inner to the outer edge. Compaction shall continue until the density achieved is at least 100 percent of the maximum dry density of the material as per IS:2720 (Part 7). The suitability of a particular compaction equipment and number of passes required may be verified on a test strip. Ideally not more than 60 minutes shall elapse between the start of moist mixing and start of compaction process. Care shall be taken to see that compaction is completed within 3 hours of mixing or such shorter period as may be necessary during dry weather.

During rolling, it shall be ensured that the roller does not bear directly on hardened or partially hardened treated material previously laid other than what may be necessary for achieving the specified compaction at the joint. The final surface shall be well closed, free from movement under compaction planes, ridges, cracks or loose material. All loose or segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

## **409.6 Curing**

Curing of the compacted layer shall be carried out for a minimum period of 7 days by spreading moist straw/wet gunny bags or sand and sprinkling water periodically. Curing by ponding of water shall not be permitted to avoid leaching of lime. After the curing period is over, subsequent pavement layers shall be laid as early as possible to prevent the surface from drying out. No traffic shall be allowed to ply during the curing period.

## **409.7 Construction Joint**

At the end of the day's work, a transverse construction joint for full depth shall be made by chamfering at an angle of 30°.

## **409.8 Surface finish and Quality Control of Work**

The surface finish of construction shall conform to the requirements of Section 1800.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 409.9 Strength

The Lime-flyash stabilised soil sub-base shall be tested for unconfined compressive strength (UCS) at 7 days. In case of variation from the design UCS, insitu value being lower, the pavement design shall be reviewed based on the actual UCS values. The extra pavement thickness needed on account of lower UCS value shall be constructed by the Contractor at his own cost.

### 409.10 Arrangement of Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Section 100.

### 409.11 Measurements for Payment

Lime-flyash stabilised soil subbase shall be measured as finished work in position in cubic metres.

### 409.12 Rate

The Contract unit rate for lime-flyash stabilised soil subbase shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7.

## 410 INDUSTRIAL WASTES FOR ROAD CONSTRUCTION

### 410.1 Scope

This Specification covers the techniques for incorporating (i) Fly ash (waste material from Thermal Power Stations which includes pond ash, bottom ash, fly ash and mound ash) in road embankments, subbase/base course and (ii) Metallic Slags (waste materials from metal extraction industries like Iron and Steel industries, copper smelting, zinc extraction, etc) in embankment, sub-base, base or surface course (iii) Mining, quarrying and stone processing wastes like marble slurry,, Kimberlite tailings,.(iv) Construction and demolition waste like crushed concrete, crushed material obtained after dismantling and crushing existing structures/ buildings etc., as necessary, according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer. Any of the industrials waste material to be used in road work should be 'Non Hazardous' as per MOEF Notification on Hazardous Materials (Management, Handling and Transboundary Movement) Rules, 2007. The Engineer may request for necessary test to determine whether any waste material proposed to be used fulfills the criteria for reuse as laid down by the MOEF before approving its usage.

### 410.2 Definition

Industrial Wastes for purposes of this Specification may be defined as waste materials having requisite engineering properties for use in rural road works in the vicinity of the industries/ plants producing these waste materials.

## 410.3 Materials

### 410.3.1 *Flyash*

### *410.3.1.1 Use in flyash embankment construction*

While the quality of flyash varies a great deal from plant to plant, typical geotechnical properties of flyash are given in **Table 400.18**. The information on flyash required by the Engineer for flyash embankment construction shall be as covered in Clause 306.2.1.

**Table 400.18 Typical Geotechnical Properties of Flyash**

| Parameter | Normal Range |
|---|---|
| Specific Gravity | 1.90-2.55 |
| Plasticity | Non-Plastic |
| Maximum Dry Density (gm/cc) | 0.9-1.60 |
| Optimum Moisture Content (%) | 38.0-18.0 |
| Cohesion (kN/m$^2$) | Negligible |
| Angle of internal Friction (j) | 30°-40° |
| Coefficient of Consolidation $C_V$ (cm$^2$/sec) | $1.7 \times 10^{-5}$–$2.0 \times 10^{-3}$ |
| Compression Index $C_C$ | 0.05-0.40 |
| Permeability (cm/sec) | $8 \times 10^{-6}$–$7 \times 10^{-4}$ |
| Particle Size Distribution (% of materials) | |
| Clay size fraction (less than 0.002 mm) | 1-10 |
| Silt size fraction (0.075 to 0.002 mm) | 8-85 |
| Sand size fraction (4.75 to 0.075 mm) | 7-90 |
| Gravel size fraction (80 to 4.75 mm) | 0-10 |
| Coefficient of Uniformity | 3-11 |

### *410.3.1.2 Use in lime-flyash stabilised soil sub-base*

The chemical and physical requirements for flyash as a pozzolana are given in **Tables 400.15 and 400.16** in Clause 409.3.1.

### *410.3.1.3 Use in lime-flyash bound macadam*

The filler used shall be a mixture of flyash, lime and soil/moorum. The flyash shall conform to the requirements given in **Tables 400.15 and 400.16** of Clause 409.3.1. Typical proportions of dry lime, flyash and soil/moorum in the filler are 1:2:9 (by weight).

*410.3.1.4* Apart from these applications, fly ash/pond ash/bottom ash can also be used for (a) Mechnical stabilization as a component of Sub-base layer (Clause 401 or 402), Cement Stabilization (Clause 404).

### 410.3.2 *Slag*

Slag can be used as pavement material in a variety of forms. It can be used as a base or sub-base material. The broad types of slag are :

i) Blast furnace slag
ii) Granulated blast furnace slag (GBFS)
iii) Steel slag

Some varieties of steel slag could be found lacking in stability in the presence of water owing to the hydration of calcium oxide. However, if such steel slags are left for weathering in stockpiles for sufficiently long period of time, these could be rendered suitable for use in road construction works.

Air-cooled blast furnace slag and weathered steel slag can be used as coarse aggregate for the construction of sub-base and base courses. Crushed slag shall meet the requirements specified in Clause 405.

Granulated blast furnace slag, which is a pozzolanic material, can be stabilised using lime and used for construction of stabilised layers and lime-GBFS base/sub-base. GBFS can also be used in place of granular sub-base provided it meets the CBR requirements.

**410.3.3** Other industrial wastes mentioned above (metallic slags, quarrying and mining wastes, Construction & demolition waste etc) can be used in the following form;

i) In Soil-Aggregate Base/Surface : Clause 402 Shall Apply
ii) In WBM Construction : Clause 405 shall apply
iii) In Cement Bound Granular Material : Clause 404 shall apply

## 410.4 Construction Operations

### 410.4.1 *Use of flyash*

i) In flyash embankment construction : Clause 306.4 shall apply
ii) In Lime-flyash stabilised soil sub-base/ base : Clause 409.5 shall apply
iii) In Lime-flyash bound macadam : Clause 405.3 shall apply except that the filler material shall be a mixture of lime, flyash and soil/ moorum (1:2:9)

### 410.4.2 *Use of crushed slag*

i) In Soil-Aggregate Base/Surface : Clause 402.4 shall apply
ii) In WBM construction : Clause 405.3 shall apply
iii) In Cement Bound Granular Material : Clause 404.3 shall apply

### 410.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 410.6 Strength

In case of lime-flyash stabilised soil, Clause 409.9 shall apply. In case of Cement Bound Granular Material, Clause 404.5 shall apply.

### 410.7 Arrangements for Traffic

During the period of construction, arrangement of traffic shall be maintained in accordance with Section 100.

### 410.8 Measurements for Payment

For the flyash embankment construction, Clause 306.9 shall apply. The subbase/base/ surface course, as the case may be, incorporating industrial wastes shall be measured as finished work in position in cubic metres.

### 410.9 Rate

For flyash embankment construction Clause 306.10 shall apply. The Contract unit rate for construction of sub-base/base/surface course incorporating industrial wastes shall be payment in full for carrying out the required operations including full compensation for all components in Clause 401.7.

## 411 CRUSHER-RUN MACADAM BASE

### 411.1 Scope

This work shall consist of furnishing, placing and compacting crushed stone aggregate base course constructed in accordance with the requirements set forth in this Specification and in conformity with the lines, grades, thicknesses and cross-sections shown on the drawings or as directed by the Engineer.

### 411.2 Materials

The material to be used for the work shall be crushed rock. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/ shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. It shall be free from any organic matter and other deleterious substances and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable base. The aggregate shall conform to the grading and quality requirements shown in **Tables 400.19 and 400.20**.

The grading to be adopted shall be as specified in the Contract.

**Table 400.19 Aggregate Grading Requirements**

| Sieve Size | Percent Passing by Weight | |
|---|---|---|
| | **53 mm Max. Size** | **37.5 mm Max. Size** |
| 63 mm | 100 | |
| 45 mm | 87-100 | 100 |
| 22.4 mm | 50-85 | 90-100 |
| 5.6 mm | 25-45 | 35-55 |
| 710 micron | 10-25 | 10-30 |
| 90 micron | 2- 5 | 2-5 |

**Table 400.20 Physical Requirements of Coarse Aggregates for Crusher-Run Macadam Base**

| | Test | Test Method | Requirement |
|---|---|---|---|
| 1) | Aggregate Impact Value or IS:5640 | IS:2386 (Part 4) | 30 maximum |
| 2) | Flakiness Index | IS:2386 (Part 1) | 25 maximum |
| 3) | Water Absorption* | IS:2386 (Part 3) | 2 percent maximum |
| 4) | Liquid Limit of Material Passing 425 micron | IS:2720 (Part 5) | Not more than 25 |
| 5) | Plasticity Index of Material Passing 425 micron | IS:2720 (Part 5) | Not more than 6 |

* If the water absorption is more than 2 percent, soundness test shall be carried out as per IS:2386 (Part 5)

## 411.3 Construction Operations

### 411.3.1 *Preparation of sub-base/subgrade*

Any ruts, deformations or soft yielding places which occur in the sub-base or subgrade shall be corrected and compacted to the required density before the aggregate base course is placed thereon.

### 411.3.2 *Spreading, watering, mixing and compaction*

The aggregate shall be uniformly deposited on the approved sub-base/subgrade by means of the hauling vehicle with or without spreading devices. Aggregate will be distributed over the surface to the depth specified on the drawings or as directed by the Engineer.

After the base course material has been deposited, it shall be thoroughly mixed to full depth of the layer by alternately blading the entire layer to the centre and back to the edges of the road. It shall then be spread and finished to the required cross-section by means of tractor with grader attachment.

Water shall be applied prior to and during all blading and processing operations to moisten the material sufficiently to prevent segregation of the fine and coarse particles. Water shall be applied in sufficient amounts during construction to assist in compaction.

Compaction shall commence immediately after the spreading operation. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity roller. The speed of the roller shall not exceed 5 km per hour. Each layer of material shall be compacted to not less than 100 percent of the maximum dry density as determined by IS:2720 (Part 7).

### 411.4 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1800.

### 411.5 Arrangements for Traffic

During the period of construction, arrangement for traffic shall be provided and maintained in accordance with Section 100.

### 411.6 Measurements for Payment

Crusher-run macadam base shall be measured as finished work in position in cubic metres.

### 411.7 Rate

The Contract unit rate for crusher run macadam base shall be payment in full for carrying out the required operations including full compensation for items as in Clause 401.7.

## 412 BRICK SOLING

### 412.1 Scope

This work shall consist of laying brick soling layer on prepared subgrade in accordance with the requirements of these Specifications. The bricks shall be laid in one or more layers as soling according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

### 412.2 Materials

Burnt clay bricks shall conform to the requirements of IS:1077, except that the minimum compressive strength, when tested flat shall not be less than 8.4 MPa for individual bricks and 10.5 MPa for average of 5 specimens. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck. The size may be according to the local practice with a tolerance of ± 5 percent.

### 412.3 Setting Out

The edges of the soling shall be marked out with reference to the centre line by means of string and stakes. The lines shall be correctly ranged.

### 412.4 Preparation of Surface

The subgrade, to receive the brick soling shall be prepared to the required grade and camber and cleaned of all dust, dirt and other extraneous matter. Any ruts or soft yielding spots that may have appeared due to improper drainage or other reasons shall be corrected and rolled until firm, to the satisfaction of the Engineer.

### 412.5 Provision of Lateral Confinement

The side shoulders shall be constructed in advance to a thickness corresponding to the brick soling layer. The inside edges of the shoulders shall be trimmed vertical and any spillage over the included area removed. Alternatively, mud walls may be constructed to provide lateral confinement. Any excavation into the finished formation shall not be permitted. The compacted surface shall be scarified and levelled to proper camber and grade before laying the brick soling layer.

### 412.6 Laying

Bricks shall be set close to each other in herring bone bond or in header and stretcher bond laid on edge or flat in layer(s) as specified. The bricks shall be hand laid with no joint exceeding 10 mm in thickness.

### 412.7 Spreading Sand

After arranging the bricks in the specified pattern, sand or earth, free from clay with a Plasticity Index not exceeding 6 shall be spread over the surface to a thickness of about 25 mm so that the joints may be filled up by the sand working in. Sand shall be allowed to remain as a protective covering to the soling till such time as a subsequent pavement layer is laid over the soling. No traffic shall be allowed and the soling lightly rammed so that the sand works into the interstices.

### 412.8 Surface Evenness

The finished surface shall be checked for the longitudinal and cross profiles.

The maximum allowable difference between the brick soling surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centre line, at points decided by the Engineer shall be 10 mm.

### 412.9 Measurements for Payment

Laying of brick soling shall be measured in square metres of the area covered. Making of any mud walls shall be considered incidental to the work and no extra payment shall be made for it.

### 412.10 Rate

The contract unit rate for brick soling shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7.

## 413 STONE SET PAVEMENT

### 413.1 General

A Stone Set Pavement is best suited to areas with slow moving vehicles and low volume traffic, where good quality stones are locally available and craftsmen with knowledge of stone paving are available.

### 413.2 Scope

This Specification shall apply to the construction of Stone Set Pavement with a total pavement crust comprising of 100 mm compacted Granular Sub-base, 75 mm compacted Water Bound Macadam (Grade II) Base and 150 mm thick hammer-dressed Stone sets paved on a bedding sand layer over the WBM Base. This work shall be finished in accordance with the requirements of these Specifications and in conformity with the lines, grades, cross-sections and thickness as per approved plans or as directed by the Engineer.

### 413.3 Materials

For the Granular Sub-base, Clause 401.2 shall apply. For the Water Bound Macadam (Grade II) Base, Clause 405.2 shall apply.

Stone sets shall be rectangular in shape, 250 mm to 300 mm long, 150 mm to 200 mm wide and 150 mm deep, with tolerance plus or minus 12 mm. The Stone sets shall be hard with an Aggregate Impact Value not more than 30 (IS:2386 Part 4), Polished Stone Value not less than 55 (BS 812 Part 114) and Water Absorption not more than 2 percent (IS:2386 Part 3). The types of Stones normally used are Granite, Basalt, Sandstone and Limestone. Sedimentary stone shall in no case be used. The Stone sets shall be hammer dressed on top to the extent that maximum depression of the dressed surface from a straight edge applied across any part of the surface for testing does not exceed 20 mm. The dressing on the sides shall be similarly carried out, so as to obtain a mortar joint not exceeding 20 mm in width.

### 413.4 Construction Operations

For the preparation of subgrade and construction of 100 mm thick compacted Granular Sub-base, Clause 401.4 shall apply.

For the construction of 75 mm thick compacted Water Bound Macadam (Grade II) Base, Clause 405.3 shall apply.

The hammer-dressed stones are laid in the herringbone or stretcher bond pattern with the rows running either across or at 45° to the axis of the road. The stones are compacted into the properly graded coarse bedding sand over the WBM base, bounded by edgestones, using suitable compacting devices. The compacted thickness of bedding sand shall be 40 mm. The joint gaps shall be filled with fine sand, stone dust, sand-cement mortar or hot sand-bitumen mix as specified in the Contract. In case of application of sand-cement mortar for filing joints, moist curing for minimum one week has to be ensured. Stone set shall be laid in sections not exceeding 12 m in length, with longitudinal axis of the stone sets parallel to the length of the road. Edgestones shall be 350 mm to 400 mm long, 150 mm to 200 mm wide and depth not less than 350 mm, laid with their longitudinal axis parallel to the length of the road.

### 413.5 Surface Evenness

The surface finish of construction shall conform to the requirements of Section 1800.

### 413.6 Measurements for Payment

The measurements for payment in respect of Granular Sub-base and the Water Bound Macadam Base shall be as per Clauses 401.8 and 405.6 respectively. The stone-sett paving shall be measured as finished work in position in square metres.

### 413.7 Rate

The Contract unit rate for the Stone-Sett Pavement shall be payment in full for carrying out the required operations including full compensation for all the components listed in Clause 401.7.

## Annexure-400.1

(Clauses 403.3.2, 404.3.2 and 409.5.3)

## Method of Sieving for Wet Soils to Determine the Degree of pulverisation

1) A sample of pulverised soil approximately 1 kg in weight should be taken and weighed ($W_1$).

2) It should be spread on the sieve and shaken gently, care being taken to break the lump of soils as little as possible. Weight of soil retained on the sieve should be recorded ($W_2$). Lumps of finer soils in the retained material should be broken until all the individual particles finer than the aperture size of the sieve are separated.

3) The soil should again be placed on the sieve and shaken until sieving is complete. The retained material should be weighed ($W_3$).

4) Weight of soil by percent passing the sieve can than be calculated from the expression:

$$\frac{(W_1 - W_2) \times 100}{(W_1 - W_3)}$$

# 500

# BITUMINOUS SURFACING COURSES

## 501 PREPARATION OF SURFACE

### 501.1 Scope

This work shall consist of preparing an existing granular or black-topped surface in advance of laying a bituminous course. The work shall be performed on such widths and lengths as shown on the drawings or as instructed by the Engineer. The existing surface shall be firm and clean, and treated with Primer and /orTack Coat as specified in the contract or as directed by the Engineer.

### 501.2 Preparation of Surface

### 501.2.1 *Preparing existing granular surface*

Where the existing surface is granular, all loose materials shall be removed and shall be cleared of all loose and extraneous matter and the surface lightly watered, in case, the profile corrective course to be provided as a separate layer is also granular. The surface finish of all granular layers on which bituminous works are to be placed shall be free from dust. All such layers must be capable of being swept, after the removal of any non-integral loose material, by means of a mechanical broom, without shedding significant quantities of material and dust removed by air jet, or other means approved by the Engineer.

After cleaning, the surface shall be correct to line, level and cross-slope, within the tolerances specified for base course.

Where the profile corrective course of bituminous material is to be laid over the existing granular surface, the latter shall, after removal of all loose material, be primed in accordance with Clause 502.

### 501.2.2 *Scarifying existing bituminous surface*

Where specified or shown on the drawings, the existing bituminous layer in the specified width and depth shall be removed with care and without causing undue disturbance to the underlying layer, by a suitable method approved by the Engineer. After removal of all loose and disintegrated material, the underlying layers which might have been disturbed, shall be suitably removed and compacted to the specified line, level and cross-slope. After supplementing the base material as necessary with suitable fresh stone aggregates, the compacted finished surface shall be primed in accordance with Clause 502. Reusable material shall be stacked as directed by the Engineer within 1000 m of their origin.

### 501.2.3 *Preparing existing bituminous surface*

Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed as outlined in Clauses 501.2.3.1 and 501.2.3.2.

*501.2.3.1* *Filling potholes and patch repairs*

a) **Preparation of the area for pothole and patch repair**

Pothole and patch repair area shall be inspected and all loose material removed. The area shall be cut/ trimmed with hand tools suitable for the purpose. All the defective material responsible for the failure shall be removed. The excavated area shall have rectangular shape and the edges with vertical sides. The area shall be thoroughly cleaned to remove all dust and loose extraneous particles with brush, compressed air or any appropriate method as approved by the Engineer. The granular layer below the bituminous layers which has been removed shall be replaced using the same material or material of equivalent specification, and shall be compacted to the standard of original specification before laying the bituminous layer, the area shall be tacked or primed as specified, depending upon whether the lower area is bituminous or granular in nature. The sides shall be applied with a tack coat material using a hand brush/sprayer. The prime coat and tack coat shall conform to Clauses 502 and 503 respectively of these Specifications.

b) **Backfilling operation**

The mixture to be used in bituminous patching shall be either a hot mix or cold mix in accordance with the appropriate Clauses of these Specifications. Mixing shall be done in a plant of appropriate design and adequate capacity. The bituminous mixture shall be placed in layers of thickness not more than 100 mm (loose) and shall be compacted in layers with static three wheeled roller of 80-100 kN weight/walk-behind roller/ vibratory plate compactor/tamper/power rammer to meet the compaction standards defined in the appropriate Clauses of these Specifications. While placing the final layer, the mix shall be spread to protrude slightly above the surface so that after rolling, the finished surface shall be flush with the adjoining surface. If the area is large, the spreading and levelling shall be done using hand shovels and wooden edges. Where required, a seal coat shall be applied as per Clause 508. The finished surface evenness shall be checked using a 3 m straight edge.

501.2.3.2 *Crack sealing*

a) **Fine cracks less than 3 mm in width**

Sealing of fine cracks shall be done by applying fog Seal. Fog Seal is a very light application of low viscosity slow setting emulsion, for sealing cracks less than 3 mm in width. The slow setting emulsion shall conform to IS:8887. The surface on which the fog seal is to be applied shall be thoroughly cleaned with compressed air, scrubbers, etc. The cracks shall be cleaned with a pressure air jet to remove all dirt, dust, etc. The fog seal shall be applied with emulsion at a rate 0.5-1.0 litres/ $m^2$ using equipment such as pressure tank fitted with flexible hose and spray bar or lance. For sites at sub-zero temperature, crack sealing by medium curing cutback as per IS:217 shall be permissible.

b) **Wide cracks**

For wider cracks, in excess of an average of 3 mm in width, the application of emulsion may be preceded by an application of crusher dust or other fine material approved by the Engineer. The bituminous emulsion for use in crack sealing shall be of a low viscosity slow setting type as per IS:8887. For sites at sub-zero temperature, the use of medium curing cutback as per IS:217 shall be permissible. Dust for crack filling when used, shall be crusher dust or some other fine material, approved by the Engineer, passing 4.75 mm sieve but with a maximum of ten percent passing the 0.075 mm sieve. Dust or other suitable fine material shall be placed in the cracks before the application of binder and the cracks filled to a level approximately 5 mm below road surface level. The surface of the road shall be swept clear of dust prior to the application of binder. Binder shall be poured into the cracks, taking care to minimize spillage. If spillage onto the road surface does occur, dust shall be applied to the excess bitumen until it is blotted up.

Where wide cracks occur in isolated areas, these shall be cut and patched as per Clause 501.2.3.1.

## 501.3 Profile Corrective Course

Where specified, a Profile Corrective Course shall be provided prior to laying of bituminous surfacing.

**501.3.1** The profile corrective course is essentially a levelling course laid to varying thickness as shown on the drawings for correcting the existing pavement profile which has either lost its shape or has to be given a new shape to meet the requirement of specified lines, grades and cross-sections. It shall be differentiated from the strengthening course or other type of structural pavement course needed as a remedial measure against inherent deficient and/or distressed pavement. It is meant to remove the irregularity in the existing road profile.

**501.3.2** Over an existing bituminous surface, prepared as per Clause 501.2.3, the Profile Corrective Course shall be of premixed bituminous material conforming to Clause 506. Where the existing surface is granular in nature, prepared as per Clause 501.2.1, or where the old bituminous layer has been scarified as per Clause 501.2.2 and the required thickness of Profile Corrective Course is over 40 mm, the Profile Corrective Course shall be with WBM (G3) material. If, however, the required thickness of the Profile Corrective Course is less than 40 mm, the Profile Corrective Course shall be premixed bituminous material conforming to Clause 506.

### 501.3.3 *Laying the profile corrective course*

#### *501.3.3.1 On granular base*

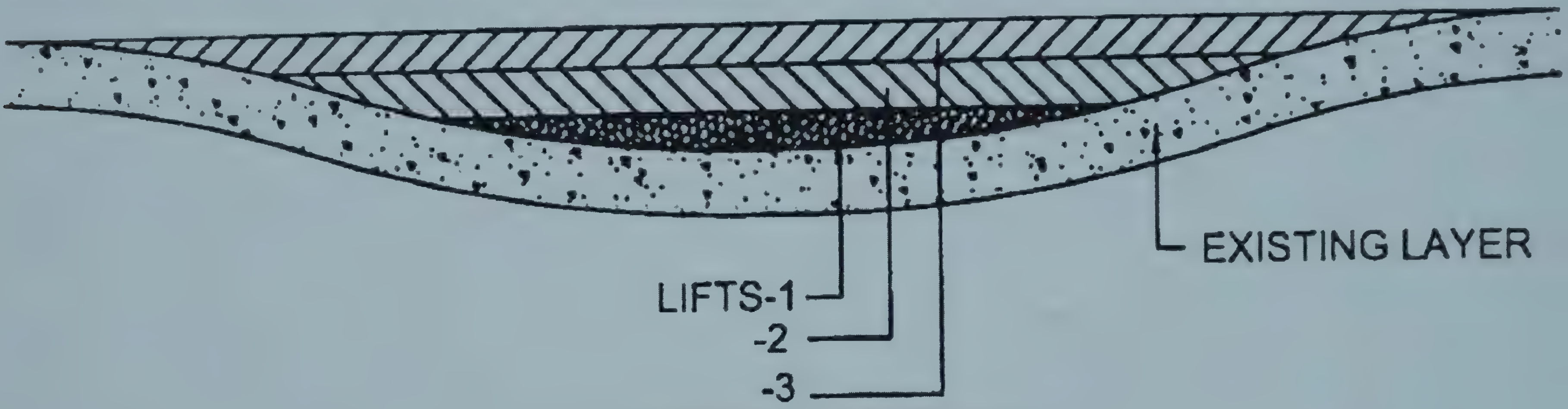
After preparing the granular surface as in Clauses 501.2.1 and 501.2.2, the profile corrective course with material as per Clause 501.3.2 shall be laid and compacted to the requirement of the particular Specification. Where a bituminous profile corrective course is to be laid over a primed granular surface, a tack coat conforming to Clause 503 shall be applied prior to laying the profile corrective course.

### *501.3.3.2 On bituminous surface*

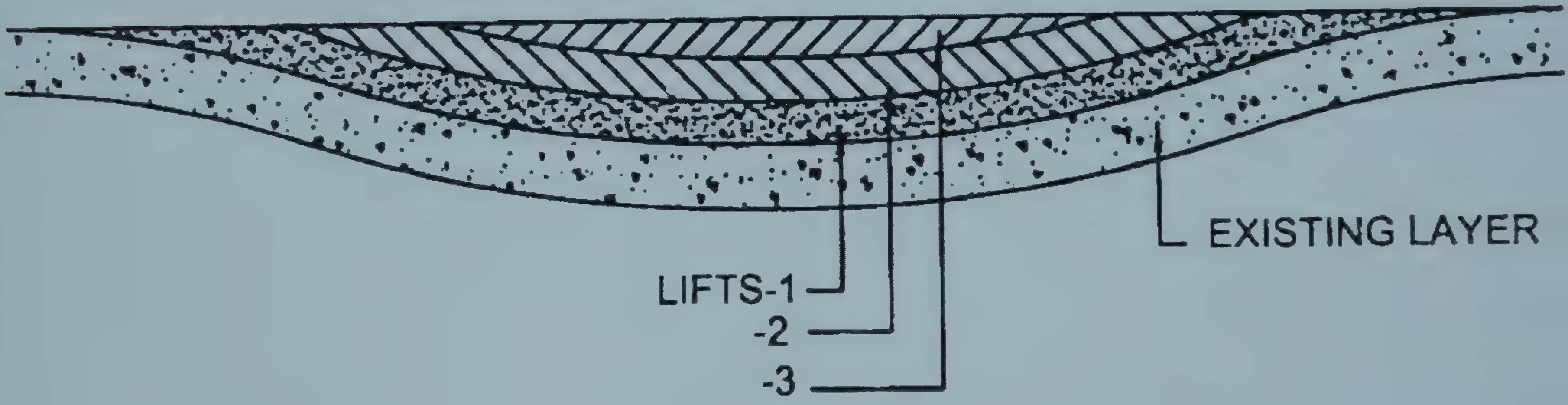
The existing bituminous surface shall be prepared as per Clause 501.2.3 and after applying a tack coat conforming to Clause 503, the bituminous profile corrective course shall be laid and compacted to the requirement of the particular Specification.

### *501.3.3.3 Correction of short sags or depressions*

Where short sags or depressions occur in the existing pavement, these shall be filled by providing corrective course in the form of flat wedges. Normally, layers in maximum thickness of each layer at any point shall not be more than 100 mm. In placing multiple lifts, the lift of shortest length (at the lowest portion of the sag/depression) shall be provided first, with successive lifts extending over and fully covering underneath layer, precluding development of a series of joints on the surfaces, as illustrated in **Fig. 500.1**.



(A) CORRECT METHOD



(B) Incorrected Method

Note : Profile Corrective course material to be in accordance with the lift thickness.

Fig. 500.1 Methods for providing corrective course for short is it sags and depressions

### *501.3.3.4 Correction for camber/superelevation*

For camber correction or correction of superelevation of the existing carriageway, the method as shown in **Fig. 500.2** shall be adopted depending on the profile of the existing carriageway.

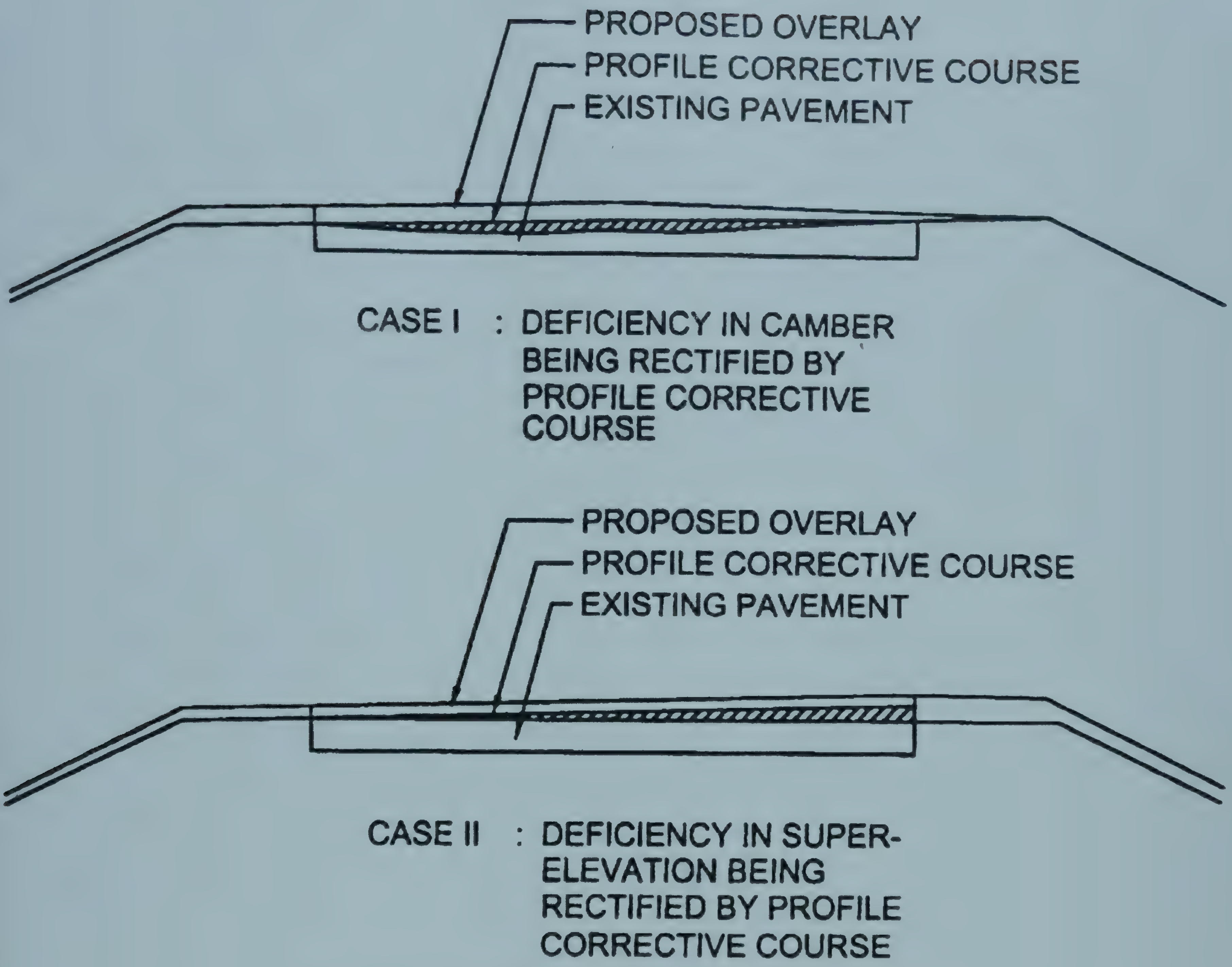

PROPOSED OVERLAY
PROFILE CORRECTIVE COURSE
EXISTING PAVEMENT
CASE I : DEFICIENCY IN CAMBER BEING RECTIFIED BY PROFILE CORRECTIVE COURSE
PROPOSED OVERLAY
PROFILE CORRECTIVE COURSE
EXISTING PAVEMENT
CASE II : DEFICIENCY IN SUPER-ELEVATION BEING RECTIFIED BY PROFILE CORRECTIVE COURSE

Fig. 500.2 Correction of camber or superelevation

#### *501.3.3.5 Covering the profile corrective course*

Work of Profile Corrective Course shall be so planned that it shall be covered by the designed base/wearing course at the earliest, before opening to regular traffic.

### 501.4 Surface Finish and Quality Control of Work

Relevant provisions of Section 1800 shall apply.

### 501.5 Arrangement for Traffic

During the construction operations, arrangement for traffic shall be made in accordance with the provisions of Section 100.

### 501.6 Environmental Protection

Detailed Guidelines on the Protection of the Environment as provided at **Annexure-500.1** are to be complied during construction of bituminous works .

### 501.7 Measurements for Payment

**501.7.1** The work of cleaning the surface using brush, compressed air or any appropriate method shall be incidental to the work of preparation of the surface.

**501.7.2** The work of filling potholes shall be measured separately and paid for in square metres or on weight basis in tonnes as specified in the Contract.

**501.7.3** The work of sealing cracks by applying fog seal shall be measured in square metres, and paid separately. The work of filling cracks larger than 3 mm width shall be measured and paid for on a linear metre/square metre basis as specified in the Contract.

**501.7.4** Scarifying existing bituminous surface shall be measured in square metres.

**501.7.5** Prime coat shall be measured as per Clause 502.7 of these Specifications.

**501.7.6** Tack coat shall be measured as per Clause 503.7 of these Specifications.

**501.7.7** Profile Corrective Course shall be measured as volume compacted in position in cubic metres or in tonnage as specified in the contract. The volume shall be worked out by plotting the exact profile of Profile Corrective Course as built up at site and superimposed on the existing pavement profile. Cross sectional areas of the profile corrective course shall be measured at an interval of 10 m centre to center on straight sections and at an interval of 5 m centre to centre on curves longitudinally and taking spot levels transversely at seven locations and at three locations for two lane and single lane carriageway respectively. The volume shall be calculated using the method of end areas.

### 501.8 Rate

**501.8.1** Contract unit rate for scarifying of existing bituminous surfaces including repairing/resetting disturbed underlying layer and also removing and stacking reusable/ unusable materials shall include cost of all labour, supply of materials needed for repair/ resetting, hire charges of tools and plant and transportation of scarified materials with all lifts and upto a lead of 1000 m.

**501.8.2** The contract unit rate for filling of potholes and patch repair shall be payment in full for :

i) supplying all materials required with all leads and lifts;

ii) all works involved including excavation, trimming, backfilling with any non-bituminous layers required, application of tack coat, priming with emulsion or cutback and backfilling with the specified bituminous materials;

iii) all labour, plants, tools, equipment, disposal of surplus material and incidentals to complete the work in accordance with the Specifications.

**501.8.3** The contract unit rate for crack sealing by application of fog seal shall be payment in full for :

i) supplying of fog seal material and all the operations for sealing of cracks; and

ii) all labour, tools, plants, equipment and incidentals to complete the work in accordance with the Specifications.

**501.8.4** The contract unit rate for sealing of cracks wider than 3 mm shall be payment in full for :

i) supplying all necessary materials for the work of filling and sealing of cracks; and

ii) all labour, tools, plants, equipment and all incidentals necessary to complete the work in accordance with the Specifications.

**501.8.5** The contract unit rate for Profile Corrective Course shall be payment in full for carrying out the required operations including full compensation for :

i) Making arrangements for traffic as per Section 100;

ii) Providing all materials to be incorporated in the work, including all leads and lifts;

iii) Preparation of the exposed surface/existing surface including all cleaning operations;

iv) All labour, tools, plants including installation of hot mix plant, power supply units equipment, testing for quality control and incidentals necessary to complete the work to the Specifications;

v) Mixing, transporting, laying and compacting the bituminous mix as specified; and

vi) Carrying out the work in part widths of road where directed by the Engineer.

## 502 PRIME COAT OVER GRANULAR BASE

### 502.1 Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a non bituminous porous granular surface preparatory to the superimposition of bituminous treatment or mix. The work shall be carried out on a previously prepared granular surface as per Clause 501.

### 502.2 Materials

### 502.2.1 *Primer*

The primer shall be cationic bitumen emulsion SS I grade, complying with IS:8887 or medium curing cut back bitumen conforming to IS:217 or as specified in the contract. The use of medium curing cut back bitumen shall be restricted only for the sites at sub zero temperatures or for emergency applications. Cutback shall not be prepared in the field. The correct quality for primer shall be decided by the Engineer and shall be such that it can be absorbed by the surface without causing run-off of excessive primer and achieve desired penetration of 8-10 mm.

**502.2.2** Quantity of SS I grade bitumen emulsion for various types of granular surfaces shall be as given in **Table 500.1A**.

**Table 500.1A Quantity of Bitumen Emulsion for Various Types of Granular Surface for Priming**

| Type of Quantity per 10 sqm | Surface (kg) |
|---|---|
| WBM/WMM | 7-10 |
| Stabilized Base | 9-12 |
| Gravel Base/Crusher Run Macadam | 12-15 |

**502.2.3** The type and quantity of cutback bitumen primer shall be as given in **Table 500.1B**.

**Table 500.1B Type and Quantity of Cutback Bitumen Primer**

| Type of Surface | Type of Cutback | Rate of Spray (kg/m$^2$) |
|---|---|---|
| WMM/WBM | MC 30 | 0.6-0.9 |
| Mechanical stabilized soil base, lime stabilized soil, soil cement and lime cement base | MC 70 | 0.9-1.2 |
| Gravel Base, Crusher Run Macadam and Crushed Rock base | MC 250 | 1.2-1.5 |

## 502.3 Weather and Seasonal Limitations

Primer shall not be applied to a wet surface (see Clause 502.4.2) or during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Surfaces which are to receive emulsion primer shall be just damp, but no free or standing water shall be present.

## 502.4 Construction

### 502.4.1 *Equipment*

The primer distributor shall be a self-propelled or tractor towed bitumen pressure distributor equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying of small areas, inaccessible to the distributor, or in narrow strips shall be permitted with a pressure hand sprayer. Use of a hand held perforated cannister shall, however, not be permitted.

### 502.4.2 *Preparation of road surface*

Immediately prior to applying the primer, the surface shall be carefully swept clean of dust and loose particles, care being taken not to disturb the interlocked aggregate. If soil/moorum binder has been used in the WBM surface, part of this should be brushed and removed upto a depth of 2 mm so as to provide good penetration.

### 502.4.3 *Application of bituminous primer*

The bituminous primer shall be sprayed/distributed uniformly over the dry surface, prepared as per Clause 502.4.2, using self-propelled or tractor towed bitumen pressure distributor fitted with spray bar capable of supplying primer at specified rates and temperature so as to provide a uniformly unbroken spread of primer. A trial section shall be laid to check the efficacy of the equipment and the rate of speed.

No heating of SS-I grade bitumen emulsion shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be effectively sprayed through the jets of the spray bar and to cover the granular base surface uniformly in the desired quantity.

### 502.4.4 *Curing of primer and opening to traffic*

A primed surface shall be allowed to cure for at least 24 hours or such other longer period as is found to be necessary to allow all the moisture/ volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall be blotted with an application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course.

## 502.5 Quality Control of Work

For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 1800 shall apply.

## 502.6 Arrangements for Traffic

During construction operations, arrangements for traffic shall be made in accordance with the provisions of Section 100.

## 502.7 Measurements for Payment

Prime coat shall be measured in terms of surface area of application in square metres.

## 502.8 Rate

The contract unit rate for prime coat shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 and as applicable to the work specified in these Specifications. Payment shall be made on the basis of the rate specified in the contract with adjustment plus or minus, for the variation between the specified quantity and the actual quantity approved by the Engineer after the trial as per clause 502.4.3.

## 503 TACK COAT

### 503.1 Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to an existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or instructed by the Engineer. The work shall be carried out on a previously prepared surface in accordance with Clause 501.

### 503.2 Materials

### 503.2.1 *Binder*

The binder used for tack coat shall be Rapid Setting Bitumen Emulsion Grade RS-1 complying with IS:8887 or suitable low viscocity paving bitumen of VG 10 grade conforming to IS:73. The use of cutback bitumen (Medium Curing grade) as per IS:217 shall be restricted only for sites at sub-zero temperature or for emergency applications as directed by the Engineer. The type and grade of binder for tack coat shall be specified in the contract.

### 503.3 Weather and Seasonal Limitations

Bituminous material shall not be applied to a wet surface or during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10ºC. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet.

### 503.4 Construction

### 503.4.1 *Equipment*

The equipment used for tack coat shall be self-propelled or tractor towed bitumen pressure distributor equipped for spraying the material uniformly at a specified rate. Hand spraying of small areas, inaccessible to the distributor, or in narrow strips, shall be permitted with a pressure hand sprayer, or as directed by the Engineer.

### 503.4.2 *Preparation of base*

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of Clause 501. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, or by other means as directed by the Engineer.

### 503.4.3 *Application of tack coat*

The binder shall be sprayed on the base at the rate specified in **Table 500.2**. The normal range of spraying temperature for a bituminous emulsion shall be 20°C–70°C. Paving bitumen if used for tack coat shall be heated to an appropriate temperature in bitumen boilers to achieve viscocity less than 2 poise. The normal range of spraying temperature for a cutback shall be 50°C-80°C. It shall be the responsibility of the Contractor to carefully handle the inflammable bituminous cutback material so as to safeguard against any fire mishap. The binder shall be applied uniformly with the aid of either self-propelled tractor towed bitumen pressure distributor capable of spraying bitumen at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen. Work should be planned so that no more than the necessary tack coat for the day's operation is placed on the surface. A spraying trial shall be carried out to demonstrate the efficacy of the equipment for uniformity of spread within specified tolerances.

Table 500.2 Rate of Application of Tack Coat

| | Type of Surface Emulsion | Rate of Spray of Binder |
|---|---|---|
| | | **(kg/m²)** |
| i) | Normal bituminous surfaces | 0.20 to 0.25 |
| ii) | Dry and hungry bituminous surfaces | 0.25 to 0.30 |
| iii) | Granular surfaces treated with primer | 0.25 to 0.30 |
| iv) | Cement Concrete Pavement | 0.30 to 0.35 |

### 503.4.4 *Curing of tack coat*

The tack coat of emulsion shall be left to cure until all the volatiles have evaporated before any subsequent construction is started. No plant or vehicles other than essentially required for construction shall be allowed on the tack coat.

### 503.5 Quality Control of Work

For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 1800 shall apply.

### 503.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Section 100.

### 503.7 Measurements for Payment

Tack coat shall be measured in terms of surface area of application in square metres.

### 503.8 Rate

The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components listed in Clause 401.7 and as applicable to the work specified in these Specifications.

## 504 BITUMINOUS MACADAM

### 504.1 Scope

This work shall consist of construction in a single course having 50 mm to 75 mm thickness of compacted crushed aggregates premixed with a bituminous binder on a previously prepared base to the requirements of Clause 501. Since the Bituminous Macadam (BM) is an open graded mix, there is a potential that it may trap water or moisture within the pavement. Therefore proper drainage arrangements adjacent to the bituminous macadam layer(s) are to be made to prevent moisture induced damage to the BM.

### 504.2 Materials

### 504.2.1 *Bitumen*

The bitumen shall be bitumen of viscocity Grade complying with Indian Standard Specifications for "Paving Bitumen" IS:73. The type and grade of bitumen to be used shall be specified in the contract. Guidelines on the choice of bitumen depending on the maximum and minimum annual temperatures ($T_{max}$ and $T_{min}$) in the area are given at **Annexure-500.2**.

### 504.2.2 *Aggregates*

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substance. Where the Contractor's selected source of aggregate have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping.

The aggregates shall satisfy the physical requirements set forth in **Table 500.3**.

**Table 500.3 Physical Requirements for Aggregates for Bituminous Macadam**

| Property | Test | Specification |
|---|---|---|
| Cleanliness | Grain size analysis Max. 5% passing 75 micron sieve | |
| Particle shape | Flakiness Index[1] | Max. 25 percent |
| Strength | Aggregate Impact Value[2] | Max. 30 percent |
| Durability | Soundness[3] | |
| | Sodium Sulphate | Max. 12 percent |
| | Magnesium Sulphate | Max. 18 percent |
| Water Absorption | Water absorption[4] | Max. 2 percent |
| Stripping | Coating and stripping of bitumen aggregate mixtures[5] | Min. retained coating 95 percent |

***Notes :***
1) IS:2386 Part 1
2) IS:2386 Part 4*
3) IS:2386 Part 5
4) IS:2386 Part 3
5) IS:6241

Where crushed gravel is proposed for use as aggregate, not less than 90 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

Fine aggregates shall consist of crushed material, passing 2.36 mm sieve and retained on 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious substances.

### 504.2.3 *Aggregate grading and binder content*

When tested in accordance with IS:2386 (Part 1) (wet sieving method), the combined aggregate grading for the particular mixture shall fall within the limits shown in **Table 500.4**. The type and quantity of bitumen are also indicated in **Table 500.4**.

**Table 500.4 Composition of Bituminous Macadam**

| IS Sieve (mm) | Cumulative Percent Passing by Weight of Total Aggregate |
|---|---|
| 26.5 | 100 |
| 19 | 90-100 |
| 13.2 | 56-88 |
| 4.75 | 16-36 |
| 2.36 | 4-19 |
| 0.3 | 2-10 |
| 0.075 | 0-5 |
| *Bitumen content, percent by weight of total mixture | 3.3-3.5 |
| Bitumen Viscocity Grade | VG-10 to VG-30 |

* *For conditions in cooler areas of India bitumen contents may be upto 0.5 percent higher, subject to the approval of the Engineer.*

The binder content shall be within a tolerance of ± 0.2 percent by weight of total mixture when individual specimens are taken for quality control tests in accordance with the provisions of Section 1800.

## 504.3 Construction Operations

### 504.3.1 *Weather and seasonal limitations*

Laying of bituminous mixtures shall not be carried out when the air temperature at the surface over which it is to be laid is below 10°C or when the wind speed at any temperature exceeds 40 km/hr at 2 m height unless specifically approved by the Engineer. Laying shall be suspended while free-standing water is present on the surface to be covered, or when rain is imminent or during rain, fog and dust storms. After rain, the surface shall be left to dry before laying shall start.

### 504.3.2 *Preparation of the base*

The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clause 501, as appropriate, and a prime coat, on granular base shall be applied in accordance with Clause 502 where specified, or as directed by the Engineer.

### 504.3.3 *Tack coat*

A tack coat in accordance with Clause 503 shall be applied as specified in the Contract or as directed by the Engineer.

The surface shall be cleaned of all loose and extraneous matter by means of mechanical brooms and dust removed by airjet or other means approved by the Engineer,

### 504.3.4 *Preparation and transportation of mix*

The pre-mixed bituminous material for Bituminous Macadam shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. In order to ensure uniform quality of the mix and proper coating of aggregates, the hot mix plant shall be calibrated from time to time. The essential features of the hot mix plants are given in IRC:27. Appropriate mixing temperatures are given in **Table 500.5** of these Specifications; the difference in temperature between the binder and aggregate should at no time exceed 14°C. If a continuous mixing plant is to be used for mixing, the Contractor must demonstrate by laboratory analysis that cold feed combined grading is within permissible grading limits and binder content is in compliance to the specified grading and bitumen content.

Bituminous Macadam shall be transported in clean insulated vehicles and unless otherwise agreed by the Engineer, shall be covered while in transit or awaiting tipping. Subject to the approval of the Engineer,a bitumen release agent, such as soap or lime water may be applied to the interior of the vehicles to prevent sticking and to facilitate discharge of the material. Care shall be taken to ensure that segregation of materials does not take place.

### 504.3.5 *Spreading*

Except in areas where a mechanical paver cannot access, premixed bituminous macadam shall be spread, levelled, and tamped by an approved self-propelled paving machine. The essential features of the paver shall conform to IRC:27. As soon as possible, after arrival at site, the materials shall be supplied continuously to the paver and laid without delay.

The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver and its method of operation, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space where a mechanical paver cannot be used, the material shall be spread, raked and levelled with suitable hand tools by experienced staff and compacted to the satisfaction of the Engineer.

However, in restricted locations and in narrow widths where the paver cannot be operated in the opinion of the Engineer, the material shall be spread and leveled with suitable hand tools by trained staff.

### 504.3.6 *Compaction*

After the spreading of mix, rolling shall be done by static three wheeled rollers of 80-100 kN weight/vibratory tandem roller of 80-100 kN weight in static mode or other approved equipment. Rolling shall start as soon as possible after the material has been spread deploying a set of rollers as the rolling is to be completed in limited time frame. The roller shall move at a speed not more than 5 km/hr. Rolling shall be done with care to avoid unduly roughening of the pavement surface.

Rolling shall commence at the edges and progress towards the centre longitudinally except that on superelevated and uni-directional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The initial or break-down rolling shall be done with static smooth wheeled roller of 80-100 kN weight/ vibratory tandem roller of 80-100 kN weight in static mode, as closely as possible to the paver and be done while the paving mix is still at a temperature that will result in maximum density without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the break-down rolling with vibratory roller of 80 to 100 kN weight or a pneumatic tyred roller of 120 to 150 kN weight with a tyre pressure of at least 0.56 MPa.The finish rolling shall be done with smooth wheel 60 to 80 kN smooth wheel roller, while material is still workable, as per the temperatures given in **Table 500.5**. The joints and edges shall be rolled with static three wheeled roller of 80-100 kN weight/vibratory tandem roller of 80-100 kN weight in static mode.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding mix material. The rolling shall then be continued till there is no crushing of aggregates and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. The roller wheel shall be kept damp if necessary to avoid bituminous material from sticking to the wheels and being picked up. In no case shall fuel, lubricating oil be used for this purpose, nor excessive water poured on the wheels. The initial wetting of the roller wheels should be done outside the compaction area.

Rolling operations shall be completed in every respect before the temperature of the mix falls below the rolling temperature given in **Table 500.5**.

**Table 500.5 Mixing, Laying and Rolling Temperatures for Bituminous Mixes**

(Degree Celcious)

| Bitumen Viscocity Grade | Bitumen Temperature | Aggregate Temperature | Mixed Material Temperature | Laying Temperature | Rolling Temperature* |
|---|---|---|---|---|---|
| VG-40 | 160-170 | 160-175 | 160-170 | 150 Min | 100 Min |
| VG-30 | 150-165 | 150-170 | 150-165 | 140 Min | 90 Min |
| VG-20 | 145-165 | 145-170 | 145-165 | 135 Min | 85 Min |
| VG-10 | 140-160 | 140-165 | 140-160 | 130 Min | 80 Min |

* *Rolling must be completed beore the mat cools to these minimum temperature*

Roller(s) shall not stand on newly laid material while there is a risk that surface will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it, as per Clause 504.3.7.

Where Modified Bitumen is used, the mixing, laying and rolling temperatures shall be as per Clause 511.

#### 504.3.7 *Joints*

For single-lane road construction, only transverse joints are made, while for double-lane road construction, longitudinal joints have also to be made in addition to transverse joints. While forming joints, it is necessary that the premixed material shall be fully compacted and the joint made flush by cutting back the exposed joint for a distance equal to the specified layer thickness, to a vertical face, discarding all loosened material. The vertical face shall be coated completely with suitable viscocitygrade hot bitumen, or cold-applied emulsified bitumen, or polymer modified adhesive bitumen tape with a minimum thickness of 2mm, before the adjacent width is laid.

### 504.4 Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Section 1800. For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 1800 shall apply.

### 504.5 Protection of the Layer

The bituminous macadam shall be covered with either the next pavement course or a wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay on account of the construction procedure adopted by the Contractor, the course shall be covered by a seal coat to the requirement of Clause 508 before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

### 504.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Section 100.

### 504.7 Measurements for Payment

The work shall be measured as finished work in cubic metres or by weight in metric tonnes as provided in the Contract.

### 504.8 Rate

The contract unit rate for the work shall be payment in full for carrying out the required operations including full compensation for :

i) Making arrangements for traffic as per Section 100 except for initial treatment to verges, shoulders and construction of diversions;

ii) Clearing of surface;

iii) Providing all materials to be incorporated in the work including arrangement for stockyards, all royalties, fees, rents where necessary and all leads and lifts;

iv) Mixing, transporting, laying and compacting the mix, as specified;

v) All labour, tools, equipment, plant including laying trials, if directed by the Engineer, installation of hot mix plant, power supply units and all machineries, incidental to complete the work to the Specifications;

vi) Carrying out the work in part widths of the road where directed;

vii) Carrying out all tests for control of quality;

viii) Provision of bitumen at 3.4 percent of weight of total mix, with the provision that the variation of quantity of bitumen will be assessed and the payment adjusted as per the rate of bitumen quoted; and

ix) All wastage in cutting of joints, etc.

## 505 SURFACE DRESSING

### 505.1 Scope

This work shall consist of the application of one coat or two coats of surface dressing, each coat consisting of a layer of bituminous binder sprayed on a previously prepared, base, followed by a cover of stone chips rolled in to form a wearing course to the requirements of these Specifications.

### 505.2 Material

### 505.2.1 *Binder*

The binder shall either be viscocity grade bitumen conforming to IS:73 or rapid setting cationic bitumen emulsion (RS-2) conforming to IS:8887 or as specified in the Contract. The grade of viscocity grade bitumen may be decided based on the lowest and highest daily mean air temperature of the project area as per table given in **Annexure-500.2**. The type of binder to be used shall be stated in the Contract, or as directed by the Engineer.

*Aggregates :* The stone chips (cover aggregate) shall conform to the requirements of Clause 504.2.2., except that their water absorption shall be restricted to a maximum of 1 percent and they shall have a Polished Stone Value of minimum 60. (BS:812 Part-114). The chips shall be single sized, clean, hard, durable, of cubical shape; and free from dust and soft or friable matter, organic or other deleterious matter and conform to one of the gradings given in **Table 500.6**. The size of the aggregate shall depend upon the type of surface on which it is laid and the traffic intensity. Guidelines for selecting the nominal size of stone chips based on the type of surface are given at **Annexure-500.3**.The nominal size of stone chips for average conditions shall be in accordance with **Table 500.6**.

*Pre-coated chips :* As an alternative to the use of an adhesion agent or wherever specified in the Contract, the chips may be pre-coated before they are spread except when the sprayed binder film is a bitumen emulsion. Pre-coating the chips may be carried out by mixing aggregates with 0.75 to 1.0 percent of bitumen by weight of chips in a suitable mixer. The chips shall be heated to 160°C and mixed with the binder heated to its application temperature. The pre-coated chips shall be allowed to cure for at least one week or until they become non sticky and can be spread easily.

**Table 500.6 Grading Requirements for Aggregates Used for Surface Dressing**

| IS Sieve Designation (mm) | Cumulative Percent by Weight of Total Aggregates Passing for the Following Nominal Sizes (mm) | | | |
|---|---|---|---|---|
| | 19 | 13 | 10 | 6 |
| 26.5 | 100 | - | - | - |
| 19.0 | 85-100 | 100 | - | - |
| 13.2 | 0-40 | 85-100 | 100 | - |
| 9.5 | 0-7 | 0-40 | 85-100 | 100 |
| 6.3 | - | 0-7 | 0-35 | 85-100 |
| 4.75 | - | - | 0-10 | - |
| 3.35 | - | - | - | 0-35 |
| 2.36 | 0-2 | 0-2 | 0-2 | 0-10 |
| 0.60 | - | - | - | 0-2 |
| 0.075 | 0-1.5 | 0-1.5 | 0-1.5 | 1-5 |
| Minimum 65% by weight of aggregate | Passing 19 mm, retained 13.2 mm | Passing 13.2 mm, retained 9.5 mm | Passing 9.5 mm, retained 6.3 mm | Passing 6.3 mm, retained 3.35 mm |

### 505.2.2 *Rates of spread of binder and chips*

The rate of spread of binder and chips will depend upon the nominal size of the aggregate and the extent of its into embedment the surface and should be determined as per the procedure detailed in IRC:110. Approximate rate of application of aggregates, and binder under average conditions are given in **Table 500.7**.

### 505.2.3 *Anti-stripping agent*

Where the proposed aggregate fails to pass the stripping test, then an approved agent (**Annexure-500.5 for details**) may be added to the binder in accordance with the manufacturer's instructions. The effectiveness of the proposed anti-stripping agent must be demonstrated by the Contractor, before approval by the Engineer.

Table 500.7 Notional Rates of Application of Binder and Aggregates

| Nominal Aggregate Size (mm) | Binder (Kg/m$^2$) | | | Aggregates Cum/m$^2$ |
|---|---|---|---|---|
| | Uncoated Aggregates | | **Coated Aggregates** | |
| | **Bitumen** | **Emulsion** | **Bitumen** | |
| 19 | 1.2 | 1.8 | 1.0 | 0.014-0.015 |
| 13 | 1.0 | 1.5 | 0.8 | 0.009-0.011 |
| 10 | 0.9 | 1.3 | 0.7 | 0.007-0.009 |
| 6 | 0.75 | 1.1 | 0.6 | 0.003-0.005 |

***Note :*** In the case of two coat Surface Dressing using emulsion, emulsion quantity for each coat may be added and 40 to 45 percent is applied in the first coat and remaining in second coat. Bitumen for coated aggregates excludes quantity of bitumen required for coating.

### 505.2 Construction Operations

**505.2.1** *Weather and seasonal limitations*

Clause 504.3.1 shall apply.

**505.2.2** *Preparation of base*

The base on which the surface dressing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Clause 501 or as directed by the Engineer. Prime coat, where needed, shall be provided as per Clause 502 or as directed by the Engineer. Where the existing surface shows signs of fatting up, the excess bitumen shall be removed as directed by the Engineer. The bituminous surface to be dressed shall be thoroughly cleaned either by using a mechanical broom and/or compressed air, or any other approved equipment/method as specified in the Contract or directed by the Engineer. The prepared surface shall be dust free, clean and dry, (except in the case of cationic emulsion where the surface shall be slightly damp).

**505.2.3** *Application of binder*

After preparation of base, paving grade binder heated to an appropriate temperature or bitumen emulsion shall be sprayed uniformly using mechanical sprayers.. When work resumes, the binder shall not be sprayed on the earlier completed surface. This can be done by covering the completed work with bitumen impregnated paper. Excessive deposit of bituminous material shall be immediately removed. The spraying temperature for the viscocity grade bitumen shall be as per **Table 500.8**.

Table 500.8 The Spraying Temperatures for Binder

| **Binder Grade** | **Whirling Spray Jets** | | **Slot Jets** | |
|---|---|---|---|---|
| | **Min°C** | **Max°C** | **Min°C** | **Max°C** |
| VG 10 | 180 | 200 | 165 | 175 |

### 505.2.4 *Application of stone chips*

A mechanically operated Chip Spreader of an approved type shall be used for the uniform spread of chippings as per the rates given in **Table 500.7**. Careful application by other approved method may be permitted with the approval of the Engineer.

Immediately after application of the binder, clean, dry chips (in the case of emulsion, the chippings may be slightly damp) shall be spread uniformly by means of a mechanical chip spreader on the surface so as to cover the surface completely with a single layer of chips.

Synchronized spreading of binder and stone chips using modern truck-mounted machine with bituminous sprayer and chip spreader shall be preferred, especially for large projects.

### 505.2.5 *Rolling*

Rolling of the chips shall preferably be carried out in accordance with Clause 504.3.6. Rolling shall commence at the edges and progress towards the centre except in super-elevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress, additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

### 505.2.6 *Application of second coat of surface dressing*

Where surface dressing in two coats is specified, the second coat should not be applied until the first coat has been open to traffic for two weeks. The surface on which the second coat is laid must be clean and free of dust. The construction operations for the second coat shall be the same as described in Clause 507.3.

## 505.3 Opening to Traffic

Traffic shall not be permitted to run on any newly surface dressed area until the following day. In special circumstances, however, the Engineer may allow the road to be opened to traffic immediately after rolling, but in such cases traffic speed shall be limited to 20 km per hour until the following day.

## 505.4 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800.

For control on the quality of materials and the works carried out, the relevant provisions of Section 1800 shall apply.

## 505.5 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Section 100.

### 505.6 Measurement for Payment

Each coat of surface dressing shall be measured as finished work for the area instructed to be covered, in square metres.

### 505.7 Rate

The Contract unit rate for surface dressing, based on the notional rates of spread for binder and each size of chippings given in Clause 507.2.4, shall be adjusted, plus or minus, for the difference between the notional rates of spread and the actual rates of spread approved by the Engineer. The adjusted rate shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 504.8.

## 506 OPEN GRADED PREMIX CARPET

### 506.1 20 mm Open-graded Premix Carpet using Bitumen

### 506.1.1 *Scope*

This work shall consist of the preparation, laying and compaction of a premix surfacing material of 20 mm thickness composed of small-sized aggregate premixed with a bituminous binder on a previously prepared base, in accordance with the requirements of these Specifications, to serve as a wearing course.

### 506.1.2 *Material*

#### *506.1.2.1 Binder*

The binder shall be a viscocity grade bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfying the requirements of IS:73. Guidance may be taken from **Annexure-500.2** for selection of appropriate grade bitumen. Where Modified Binder is specified, Clause 511 shall apply.

#### *506.1.2.2 Aggregate*

The aggregate shall conform to Clause 504.2.2 except that the water absorption shall be limited to a maximum of 1 percent.

#### *506.1.2.3 Proportioning of materials*

The materials shall be proportioned in accordance with **Table 500.9**.

**Table 500.9 Quantities of Materials Required for 10 m$^2$ of Road Surface for 20 mm Thick Premix Carpet**

| | Aggregate | Quantity |
|---|---|---|
| a) | Nominal Stone size 13.2 mm (passing 22.4 mm sieve and retained on 11.2 mm sieve) | 0.18 m$^3$ |
| b) | Nominal Stone size 11.2 mm (passing 13.2 mm sieve and retained on 5.6 mm sieve) | 0.09 m$^3$ |
| | **Total** | **0.27 m$^3$** |

| Quantity of Binder | | |
|---|---|---|
| a) | For 0.18 m$^3$ of 13.2 mm nominal size stone at 52 kg bitumen per m$^3$ | 9.5 kg |
| b) | For 0.09 m$^3$ of 11.2 mm nominal size stone at 56 kg bitumen per m$^3$ | 5.1 kg |
| | **Total** | 14.6 kg |

### **506.1.3** *Construction operations*

### *506.1.3.1* *Weather and seasonal limitations*

Clause 504.3.1 shall apply.

### *506.1.3.2* *Preparation of surface*

The underlying surface on which the bituminous surfacing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross-section in accordance with Clause 501. A prime coat where needed shall be applied in accordance with Clause 502 as directed by the Engineer.

### *506.1.3.3* *Tack coat*

A tack coat complying with Clause 503, shall be applied over the base preparatory to laying of the surfacing.

### *506.1.3.4* *Preparation of premix*

Hot mix plant of adequate capacity and type approved by the Engineer shall be used for the preparation of the mix. The hot mix plant shall have separate dryer arrangement for aggregate.

For small jobs, mini hot mix plants of 6-10 tonne per hour capacity having separate dryer for heating aggregate, bitumen boiler for heating bitumen and mixing arrangement to prepare homogenous mix may be used with the approval of the Engineer.

According to the grade of binder used, the temperature of the binder at the time of mixing, laying and compaction shall be in conformity with the temperatures given in **Table 500-5** and the difference in temperature between the binder and aggregate at no time exceeds 14°C. Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly. When Modified Bitumen is used, the application temperature shall be as per Clause 511.

The mix shall be immediately transported from the mixer to the point of use in suitable vehicles. The vehicles employed for transportation shall be clean and the mix being transported covered in transit if so directed by the Engineer.

### *506.1.3.5* *Spreading and rolling*

The pre-mixed material shall be spread on a previously prepared base as per Clause 501 by suitable means to the desired thickness, grades and cross-fall (camber) making due allowance for any extra quantity required to fill-up depressions, if any. The cross-fall should be checked by means of camber boards and irregularities levelled out. Excessive use of blades of rakes should be avoided. As soon as sufficient length of bituminous material has been laid, rolling shall commence with smooth wheeled tandem roller of 80 to 100 kN static weight, or other approved equipment. Rolling shall begin at the edge and progress towards the centre longitudinally, except that on superelevated and uni-directional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions, which become apparent, shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled and all the roller marks eliminated. In each pass of the roller, the preceding track shall be overlapped uniformly by at least one-third width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels. In no case shall fuel/lubricating oil be used for this purpose. Excess use of water for this purpose shall also be avoided.

Rollers shall not stand on newly laid material. Rolling operations shall be completed in every respect before the temperature of the mix falls below the rolling temperature indicated in **Table 500-5**. Joints along and transverse to the surfacing laid and compacted earlier shall be cut vertically to their full depth so as to expose fresh surface which shall be painted with thin coat of appropriate binder before the new mix is placed against it.

#### *506.1.3.6 Seal coat*

A seal coat conforming to Clause 508 of the type specified in the Contract shall be applied to the surface immediately after laying the surfacing.

### **506.1.4** *Opening to traffic*

No traffic shall be allowed on the road until the seal coat has been laid. After the seal coat is laid, the road may be opened to traffic according to Clause 508.

### **506.1.5** *Surface finish and quality control of work*

The surface finish of construction shall conform to the requirements of Clause 1800. For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 1800 shall apply.

### **506.1.6** *Arrangements for traffic*

During the period of construction, arrangement of traffic shall be made in accordance with the provision of Section 100.

### **506.1.7** *Measurements for payment*

Open graded premix surfacing shall be measured as finished work, for the area instructed to be covered, in square metres. The area will be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

### 506.1.8 *Rate*

The contract unit rate for open-graded premix surfacing shall be payment in full for carrying out the required operations including full compensation for components listed in Clause 504.8, as applicable to the work specified in these Specifications.

## 506.2 20 mm Cold Mixed Open Graded Premix Carpet

### 506.2.1 *Scope*

This work shall consist of the preparation, laying and compaction of an open graded premix surfacing of 20 mm thickness composed of small-sized aggregate premixed with a cationic bitumen emulsion on a previously prepared surface, in accordance with the requirements of these Specifications, to serve as a wearing course.

### 506.2.2 *Material*

*506.2.2.1 Binder*

The binder for premix wearing course shall be bitumen emulsion of Medium Setting (MS) grade complying with IS:8887 or as specified in the Contract.

*506.2.2.2 Aggregate*

The requirements of Clause 506.1.2.2 shall apply.

### 506.2.3 *Proportioning of materials*

The materials shall be proportioned as per quantities given in Table 500.10.

**Table 500.10 Quantities of Materials Required for 10 m² of Road Surface for 20 mm Thick Cold Mixed Premix Carpet**

| | Aggregate | Quantity |
|---|---|---|
| a) | Nominal Stone size 13.2 mm (passing 22.4 mm sieve and retained on 11.2 mm sieve) | 0.18 $m^3$ |
| b) | Nominal Stone size 11.2 mm (passing 13.2 mm sieve and retained on 5.6 mm sieve) | 0.09 $m^3$ |
| | **Total** | **0.27 $m^3$** |
| **Cationic Bitumen Emulsion** | | 20-23 kg |

### 506.2.4 *Construction operations*

*506.2.4.1 Weather and seasonal limitations*

Clause 504.3 shall apply except that the minimum air temperature for laying shall be 10°C. Cationic bitumen emulsion shall not normally be stored below 0°C.

### *506.2.4.2 Preparation of surface*

The underlying surface on which the premix surfacing is to be laid shall be prepared, in accordance with the requirements of Clause 504.3 for a newly primed surface.

### *506.2.4.3 Preparation of binder*

Before opening, the bitumen emulsion drum shall be rolled at slow speed, to and fro, at least 5 times, for a distance of about 10 m, to distribute any storage sedimentation.

### *506.2.4.4 Tack coat*

A tack coat complying with Clause 503, shall be applied over the surface preparatory to laying of the surfacing where specified in the Contract, or directed by the Engineer.

### *506.2.4.5 Preparation of premix*

Premixing of bitumen emulsion and aggregates can be carried out in a suitable mixer such as cold mixing plant as per IS:5435 (Revised) or concrete as approved by the Engineer.

When using concrete mixer for preparing the premix, 0.135 cum (0.09 cum of 13.2 mm size and 0.045 cum of 11.2 mm size) of aggregates per batch shall be used which quantity will cover 5 sqm of road surface with 20 mm average thickness.

The aggregates required for one batch shall be prepared adjacent to the mixer.

First the coarse aggregate of 13.2 mm size shall be placed into the mixer followed by 5 to 6.5 kg of bitumen emulsion and then the 11.2 mm size aggregate shall be added, followed by 5 to 6.5 kg of bitumen emulsion. After the materials have been mixed thoroughly, the mix shall be immediately transported to the laying site in suitable vehicles. Too much mixing shall be avoided.

### *506.2.4.6 Spreading and rolling*

The premixed bitumen emulsion and aggregates shall be spread within 10 minutes of applying the tack coat. All levelling, raking, etc. should be completed within 20 minutes of the time of mixing.

The mix should be spread on a previously prepared surface as per Clause 501 uniformly to the desired thickness, grades and crossfall (camber) making due allowance for any extra quantity required to fill up depressions, if any. The crossfall shall be checked by means of camber boards and irregularities levelled out. Too much raking is to be avoided.

The rolling shall start immediately after laying the premix with a smooth wheeled tandem roller of 80 to 100 kN static weight shall be used, unless other compaction methods are approved by the Engineer, based on the results of laying trials, if necessary. While rolling, wheels of roller should be clean and kept moist to prevent the premix from adhering to the wheels. In no case shall fuel/lubricating oil be used for this purpose. Use of water for this purpose shall be strictly limited to an absolute minimum.

Rolling shall commence at the edges and progress towards the centre longitudinally except in the case of superelevated and uni-directional cambered sections where rolling shall be carried out from the lower edge towards the higher edge, parallel to the centre line of the road.

After one pass of roller over the whole area, depressions or uncovered spots shall be corrected by adding premix material. Rolling shall be continued until the entire surface has been rolled to maximum compaction and all the roller marks eliminated. In each pass of the roller the preceding track shall be overlapped uniformly by at least 1/3 width. Roller(s) shall not stand on newly laid material. Joints both longitudinal and transverse to the road sections laid and compacted earlier, shall be cut vertically to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of binder before the new mix is placed against it.

#### *506.2.4.7 Seal coat*

A seal coat, conforming to Clause 508 as specified in the Contract, shall be applied 4 to 6 hours after laying the premix carpet.

### **506.2.5** *Opening to traffic*

Traffic may be allowed after 6 to 8 hours after laying the seal coat. In case of single lane roads, traffic may be allowed after 4 hours or when the mix is properly set and the speed is restricted to not more than 16 km per hour. If any premix material is picked up by vehicle tyres, the spot shall be filled up by new mix. If traffic conditions permit, the road shall not be opened until a full 24 hours after laying.

### **506.2.6** *Surface finish and quality control*

The surface finish of construction shall conform to the requirements of Section 1800.

For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 1800 shall apply.

### **506.2.7** *Arrangements for traffic*

During the period of construction, arrangements of traffic shall be made in accordance with the provisions of Section 100.

### **506.2.8** *Measurements for payment*

Cold mixed open graded premix carpet shall be measured as finished work, for the area specified to be covered in the Contract. The area will be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

### **506.2.9** *Rate*

The contract unit rate for cold mixed open graded premix carpet shall be payment in full for carrying out the required operations including full compensation for components listed in Clause 504.8, as applicable to the work specified in these Specifications.

## 507 MIX SEAL SURFACING

### 507.1 Scope

**507.1.1** This work shall consist of the preparation, laying and compaction of close-graded premix surfacing material of 20 mm thickness composed of graded aggregates premixed with a bituminous binder on a previously prepared surface, in accordance with the requirements of these Specifications, to serve as a wearing course.

**507.1.2** Mix Seal Surfacing shall be of Type A or Type B as specified in the Contract documents.

### 507.2 Materials

**507.2.1** *Binder*

The provisions of Clause 506.1.2.1 shall apply.

**507.2.2** *Coarse aggregates*

The provisions of Clause 506.1.2.2 shall apply.

**507.2.3** *Fine aggregates*

The fine aggregates shall consist of crushed rock, quarry sands, natural gravel/sand or a mixture of both. These shall be clean, hard, durable, un-coated, mineral particles, dry and free from injurious, soft or flaky particles and organic or deleterious substances.

**507.2.4** *Aggregate gradation*

The coarse and fine aggregates shall be so graded or combined as to conform to one or the other gradings shown in **Table 500.11** as specified in the contract.

**Table 500.11 Aggregate Gradation**

| IS Sieve Designation | Cumulative percent Passing by Weight of Total Aggregate | |
|---|---|---|
| | Type A | Type B |
| 13.2 mm | - | 100 |
| 11.2 mm | 100 | 88-100 |
| 5.6 mm | 52-88 | 31-52 |
| 2.8 mm | 14-38 | 5-25 |
| 0.090 mm | 0-5 | 0-5 |

**507.2.5** *Proportioning of materials*

The total quantity of aggregates used for Type A or B Mix Seal Surfacing shall be 0.27 cum per 10 sqm area. The quantity of binder used for premixing shall be 22 kg and 19 kg per 10 sqm area for Type A and Type B surfacing respectively.

### 507.3 Construction Operations

The provisions of Clause 506.1.3 shall apply, except that the laying of Mix Seal Surfacing shall be carried out by a mechanical paver.

### 507.4 Opening to Traffic

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Speed restrictions may be imposed at initial stages.

### 507.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800. For control on the quality of materials supplied and the works carried out, the relevant provisions of Section 1800 shall apply.

### 507.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be in accordance with the provisions of Section 100.

### 507.7 Measurements for Payment

Mix Seal Surfacing, Type A or Type B shall be measured as finished work, for the area specified to be covered, in square metres at a specified thickness. The area shall be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

### 507.8 Rate

The contract unit rate for Mix Seal Surfacing, Type A or Type B shall be payment in full for carrying out the required operations including full compensation for components listed in Clause 504.8, as applicable to the work specified in these Specifications.

## 508 SEAL COAT

### 508.1 Scope

**508.1.1** This work shall consist of the application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall (camber).

**508.1.2** Seal coat shall be of any of the three types specified below :-

Type A : Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chips.

Type B : Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

Type C : Premixed seal coat comprising of an application of 6.7 mm size stone chips premixed with bituminous binder.

### 508.2 Material

#### 508.2.1 *Binder*

The requirements of Clauses 506.1.2.1 and 506.2.2.1 shall apply. The required quantities of binder shall be as given in **Table 500.12**.

**Table 500.12 Required Quantities of Binder**

| Type of Seal Coat | Per 10 $m^2$ Area | |
|---|---|---|
| | Bitumen (kg) | Bituminous Emulsion (kg) |
| Type A : Liquid Seal Coat | 9.8 | 12 to 14 |
| Type B : Premix Seal Coat | 6.8 | 10 to 12 |
| TypeC : Premixed Seal Coat using stone chips of 6.7 mm size | 4.5 by weight of total mixture | 9 to 11 |

#### 508.2.2 *Stone chips for Type A seal coat*

The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They should be free of soft or disintegrated stone, organic or other deleterious matter. Stone chips shall be 6.7 mm size defined as 100 percent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cum per 10 sqm area. The chips shall satisfy the quality requirements in **Table 500.3** except that the upper limit for water absorption value shall be 1 percent.

#### 508.2.3 *Aggregate for Type B seal coat*

The aggregate shall be sand or grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky/elongated material, organic matter or other deleterious substances. The aggregate shall pass 2.36 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cum per 10 sqm area.

#### 508.2.4 *Stone chips for Type C seal coat*

The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. The stone chips shall be free of soft or disintegrated stone, organic or other deleterious matter and shall be of 6.7 mm size defined as 100 percent passing through 9.5 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cum per 10 sqm area. The chips shall satisfy the quality requirements in **Table 500.3** except that the upper limit for water absorption value shall be 1 percent.

### 508.3 Construction Operations

#### 508.3.1 *Weather and seasonal limitations*

The requirements of Clause 504.3 shall apply.

### 508.3.2 *Preparation of surface*

The seal coat shall be applied immediately after laying the bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other extraneous matter with mechanical broom/compressed air/hand broom.

### 508.3.3 *Construction of Type A seal coat*

a) **Bitumen as the Binder**

Bitumen according to the grade of bitumen used shall be heated to the temperature as per **Table 500.5** and sprayed at the rate specified on the dry surface in a uniform manner with a self-propelled or tractor towed bitumen pressure distributor fitted with a spray bar as approved by the Engineer. Immediately after the application of binder, stone chips, which shall be clean and dry, shall be spread uniformly at the rate specified on the surface preferably by means of self-propelled chip spreader/ tipper fitted with chip spreading arrangement or towed mechanical chip spreader so as to cover the surface completely. If necessary, the surface shall be brushed to ensure uniform spread of chips. Immediately after the application of the cover material, the entire surface shall be rolled with a smooth wheeled roller of 80 to 100 kN weight or other equipment approved by the Engineer after laying trials if required. Rolling shall commence at the edges and progress towards the centre except in superelevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress, additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

b) **Bituminous Emulsion as the Binder**

When a bitumen emulsion is used as binder, it shall be sprayed uniformly on the prepared base by mechanical sprayers. An emulsion tank of 30 litre capacity pressurized by compressed air from a hand pump and a 12 mm flexible pipe with a spray nozzle is a simple and efficient arrangement for spraying. Immediately after spraying of bituminous emulsion, aggregate shall be spread uniformly and evenly by mechanical means to cover the surface completely and evenly. Any oversize aggregate if observed, shall be removed. Immediately after the application of cover material, the surface shall be rolled as per the procedure as described in para (a) above.

### 508.3.4 *Construction of Type B seal coat*

a) **Bitumen as the Binder**

A mixer of adequate capacity and type approved by the Engineer shall be used for preparation of the mixed material. The plant shall have separate dryer arrangements for heating aggregate. The binder shall be heated in boilers of suitable design, approved by the Engineer to the temperature appropriate to the grade of bitumen as per **Table 500.5** or as directed by the Engineer. The aggregates shall be dry and suitably heated to a temperature as per **Table 500.5** or as directed by the Engineer before these components are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued until the latter are thoroughly coated with the former. The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed. As soon as a sufficient length has been covered with the premixed material, the surface shall be rolled with a smooth wheeled tandem roller of 80-110 kN weight or other equipment as approved by the Engineer after laying trials if required. Rolling shall be continued until the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

b) **Bituminous Emulsion as the Binder**

When bitumen emulsion is used as the binder, premixing with aggregates shall be done in a suitable mixer such as cold mixing plant as per IS:5435 or concrete mixer. The mixer shall be located near the site of work. The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed. All levelling, raking, etc. shall be completed before the mix becomes unworkable. The rolling shall be done as per Clause 506.2.4.6 of these Specifications. Rolling shall be continued until the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

**508.3.5** *Construction of Type C seal coat using stone chips of 6.7 mm size*

a) **Bitumen as the Binder**

The provisions of Clause 506.1.3 shall apply for preparation of premix, spreading and rolling. A smooth uniform closed surface shall be ensured at completion of rolling operation.

b) **Bitumen Emulsion as the Binder**

The provisions of Clause 506.2.4 shall apply for preparation of premix, spreading and rolling. A smooth uniform closed surface shall be ensured at completion of rolling operation.

### 508.4 Opening to Traffic

In the case of Type B and Type C seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. In the case of Type A seal coat, traffic shall not be permitted to run on any newly sealed area until the following day. In special circumstances, however, the Engineer may open the road to traffic immediately after rolling, but in such cases traffic speed shall be rigorously limited to 16 km per hour until the following day.

### 508.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800.

For control on the quality of materials supplied and the works carried out, the relevant provisions of Section 1800 shall apply.

### 508.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Section 100.

### 508.7 Measurements for Payment

Seal coat, Type A, Type B or Type C, shall be measured as finished work, over the area specified to be covered, in square metre. Alternatively, Type 'C' seal coat can also be measured as finished work in cum or by weight in metric tonnes as provided in the Contract.

### 508.8 Rate

The contract unit rate for seal coat Type A, Type B and Type C shall be payment in full for carrying out the required operations including full compensation for components listed in Clause 504.8, as applicable to the work specified in these Specifications.

## 509 25 MM SEMI-DENSE BITUMINOUS CONCRETE

### 509.1 Scope

This work shall consist of preparation, laying and compaction of 25 mm thick layer of Semi Dense Bituminous Concrete composed of mineral aggregate and appropriate bituminous binder mixed in a hot mix plant and laid with a mechanical paver to be laid on a previously prepared bituminous bound surface.

### 509.2 Materials

#### 509.2.1 *Binder*

The provisions of Clause 506.1.2.1 shall apply.

#### 509.2.2 *Coarse aggregate*

*509.2.2.1* The coarse aggregate shall consist of crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve. It shall be clean, hard, durable and have cubical shape, free from dust and soft organic and other deleterious substances. The aggregate should preferably be of low porosity. The coarse aggregate shall satisfy the physical requirements specified in **Table 500.13**.

*509.2.2.2* Where crushed gravel is proposed as aggregate, not less than 90 percent by weight of the crushed material retained on 4.75 mm sieve shall have at least two fractured faces.

**Table 500.13 Physical Properties of Coarse Aggregate**

| Property | Test | Requirement | Test Method |
|---|---|---|---|
| Cleanliness | Grain size analysis | Max. 5% passing 0.075 mm | IS:2386 Part I |
| Particle Shape | Flakiness and Elongation Index (combined) | Max. 35% | IS:2386 Part I |
| Strength * | Los Angeles Abrasion Value | Max. 35% | IS:2386 Part IV |
| | Aggregate Impact Value | Max. 27% | IS:2386 Part IV |
| Polishing | Polished Stone Value | Min. 55 | IS:2386 Part IV |
| Durability | Soundness (Either Sodium or Magnesium Sulphate) – 5 cycles | | |
| | Sodium Sulphate | Max. 12% | IS:2386 Part V |
| | Magnesium Sulphate | Max. 18% | IS:2386 Part V |
| Water absorption | Water absorption | Max. 2% | IS:2386 Part III |
| Stripping | Coating and Stripping of Bitumen Aggregate Mixtures | Min. Retained Coating 95% | IS:6241 |
| Water sensibility | Retained Tensile strength** | Min. 80% | AASHTO T283 |

***Notes:*** *The aggregate may satisfy either of the two tests.

** If the minimum retained tensile strength falls below 80 percent, use of anti-stripping agent is recommended to meet the minimum requirements.

**509.2.3** *Fine aggregate*

*509.2.3.1* Fine Aggregate shall consist of crushed or naturally occurring mineral material, or a combination of two, passing 2.36 mm sieve and retained on 0.075 mm sieve. No natural sand will be allowed in the base courses. The fine aggregate shall be clean, hard, durable, dry and free from dust and soft organic and other deleterious substances. Fine aggregate shall have a sand equivalent value not less than 50 when tested in accordance with the requirement of IS:2720 Part 37. The plasticity index of the fraction passing the 0.425 mm sieve shall not exceed 4 when tested in accordance with IS:2720 Part 5.

**509.2.4** *Filler*

*509.2.4.1* Filler shall consist of finely divided mineral matter such as rock dust, or hydrated lime or cement approved by the Engineer. The use of hydrated lime is encouraged because of its very good anti-stripping and antioxidant properties. The filler shall be graded within the limits indicated in **Table 500.14**.

**Table 500.14 Grading Requirement of Mineral Filler**

| IS Sieve (mm) | Cumulative Percent Passing by Weight of Total Aggregate |
|---|---|
| 0.6 | 100 |
| 0.3 | 95-100 |
| 0.075 | 85-100 |

*509.2.4.2* The filler shall be inert material free from organic impurities and have plasticity index, not greater than 4. Plasticity Index requirement will not apply if filler is hydrated lime or cement. Where the completed bituminous mixture fails to satisfy requirement of Moisture Susceptibility test (AASHTO T283 with freeze & thaw option), 2 percent by total weight of aggregate of hydrated lime shall be used and percentage of fine aggregate reduced accordingly. See **Annexure-500.4** for the outline of AASHTO T283.

### 509.3 Aggregate Grading and Bitumen Content

**509.3.1** The combined grading of the coarse aggregate, fine aggregate and filler, when tested in accordance with IS:2386 Part 1, wet sieving method, shall conform to limits given in **Table 500.15**.

**509.3.2** The combined aggregate grading shall not vary from the lower limit on one sieve to the higher limit on the adjacent sieve to avoid gap grading.

**Table 500.15 Aggregate Grading and Bitumen Content**

| Normal Maximum Aggregate Size* | 9.5 mm |
|---|---|
| Layer thickness | 25 mm |
| IS sieve size (mm) | Cumulative Percent by weight of total aggregate passing |
| 13.2 | 100 |
| 9.5 | 90-100 |
| 4.75 | 35-51 |
| 2.36 | 24-39 |
| 1.18 | 15-30 |
| 0.6 | |
| 0.3 | 9-19 |
| 0.15 | |
| 0.075 | 3-8 |
| Bitumen Content (Min) ** | 5% |

* Nominal maximum aggregate size is the largest specified sieve size upon which any of the aggregate material is retained.

** Corresponds to specific gravity of the Aggregate being 2.7. In case aggregates have specific gravity more than 2.7, bitumen content can be reduced proportionately. Further, for regions where highest daily mean air temperature is 30°C or lower and lowest daily mean air temperature is -10°C or lower, the bitumen content may be increased by as much as 0.5 percent.

**509.3.3** Bitumen content indicated in **Table-500.15** is the minimum only. The exact bitumen content required shall be determined following the Marshall Mix Design procedure contained in the Asphalt Institute Manual MS-2 (Sixth Edition).

**509.3.4** The fines to bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2.

## 509.4 Design of Mix

### Mix Requirements

**509.4.1** Besides conforming to the requirement of grading and quality for individual ingredients, the mix shall meet the requirement set out in **Table 500.16** depending upon the type of binder.

**Table 500.16 Requirement of the Mix Using Viscosity-Graded (VG) Paving/Modified Bitumen**

| Properties | Viscosity Grade Paving Bitumen | Modified Bitumen | | Test Method |
|---|---|---|---|---|
| | | Hot Climate | Cold Climate | |
| Compaction level (Number of blows) | 75 blows on each face of the specimen | | | |
| Minimum stability (kN at 60°C) | 9 | 12 | 10 | AASHTO T245 |
| Marshall flow (mm) | 2-4 | 2.5-4 | 3.5-5 | AASHTO T245 |
| Marshall Quotient (stability/flow) | 2-5 | 2.5-5 | | |
| % Air Voids | 3-5 | | | MS-2 and ASTM D2041 |
| % Voids filled with bitumen (VFB) | 65-75 | | | MS-2 |
| Tensile Strength Ratio | 80% (Minimum) | | | AASHTO T283 |
| Coating of Aggregate Particles with bitumen | | | 95% (Minimum) | IS:6241 |
| % voids in Mineral aggregate VMA | | | | |
| Nominal Maximum Particle size | Min. % VMA related to designed percent air voids *** | | | |
| 9.5 mm | 14 | 15 | 16 | |

*** For intermediate value of designed percentage air voids interpolate the VMA

### 509.4.2 *Binder content*

*509.4.2.1* The binder content shall be selected to obtain 4 percent air voids in the mix design and shall meet all requirements given in **Table 500.16**. The Marshall Method for designing the mix shall be adopted as described in the sixth edition of the Asphalt Institute Manual MS-2.

### 509.4.3 *Job mix formula*

*509.4.3.1* The laboratory mix design gives the proportion of the mineral aggregate combination in terms of individual sieve sizes, for actual operational purpose in the field, blending of the two or more sizes of aggregates (each size having within its range of individual sieve size) would be necessary. This blending ratio is obtained on a weight basis giving percent weight of the coarse aggregate, fine aggregate and filler needed to give the ultimate gradation. This mineral aggregate combination together with the corresponding optimum bitumen content as determined in the laboratory, constitute the job mix formula for implementation during construction. The job mix formula proposed for the use in the work shall give the following details:

1) Source and location of all materials
2) Proportions of all materials
3) Binder type and percentage by weight of total mixture
4) Coarse aggregate/fine aggregates/mineral filler as percentage by weight of total aggregate including mineral filler.
5) A single definite percentage passing each sieve for the mix aggregate.
6) The individual grading of the individual aggregate fraction and the proportion of each in the combined grading.
7) The test results of mix design such as maximum specific gravity of loose mix (Gmm), compacted specimen densities, Marshall stability, flow, air voids, VMA, VFB and related graphs, and test results of AASHTO T283 Moisture Susceptibility Test.
8) In case of batch mixer, the individual weight of each type of aggregate and binder per batch.
9) Test results of aggregates.
10) Mixing and compacting temperatures.

*509.4.3.2* Approval of the job mix formula shall be based on independent testing by the Engineer on the samples furnished by the Contractor. It should be ensured that it is based on the truly representative samples of the material that will be used for the work. New job mix formula shall be got approved whenever there is change in the material used for the work.

### 509.4.4 *Plant trial*

*509.4.4.1* Plant trial shall be carried out to establish that the plant can produce uniform mx conforming to the job mix formula. The permissible variation of the various ingredients in the actual mix from the job mix formula shall be within the limits as given in **Table 500.17**. These variations are intended to apply to individual specimen taken for quality control test in accordance with Clause 509.7.

**Table 500.17 Permissible Variation from the Job Mix Formula**

| **Description** | **Permissible Variation** |
|---|---|
| Aggregate passing | |
| 13.2 mm/9.5 mm | ± 6% |
| 4.75 mm | ± 5% |
| 2.36 mm, 1.18 mm, 0.6 mm | ± 4% |
| 0.3 mm, 0.15 mm | ± 3% |
| 0.075 mm | ± 1.5% |
| Binder Content | ± 0.3% |
| Mixing Temperature | ± 10°C |

### 509.4.5 *Laying trials*

*509.4.5.1* Laying trials shall be carried out to establish that the proposed mix can be laid and compacted. The laying trial shall be carried out in an area, which does not form a part of the work. The minimum area for laying trials shall be 100 sqm. This shall be similar to the project area on which the bituminous layer is to be laid. Methodology, equipment and mix shall be similar to those proposed for the project.

*509.4.5.2* The trials establish that the proposed laying plan, compaction plan and methodology are capable of producing satisfactory results. The density of finished paving layer should not be less than 92 percent of the average density (Sample Size N= 2) based on the theoretical maximum specific gravity of the loose mix (Gmm) obtained on the day of trial following ASTM D2041. (vide **Annexure-500.5**)

### 509.5.1 *Construction operation*

#### *509.5.1.1 Cleaning of the surface*

The surface shall be cleaned of all loose extraneous matter by means of mechanical broom and high-pressure air jet from compressor or any other approved equipment/method.

### 509.5.2 *Tack coat*

A tack coat complying with Clause 503, shall be applied over the base preparatory to laying of the surfacing.

### 509.5.3 *Preparation and transportation of mix*

The pre-mixed bituminous material for Semi Dense Bituminous Concrete shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. In order to ensure uniform quality of the mix and proper coating of aggregates, the hot mix plant shall be calibrated from time to time. The essential features of the hot mix plants are given in IRC:27. Appropriate mixing temperatures are given in **Table 500.5** of these Specifications; the difference in temperature between the binder and aggregate should at no time exceed 14°C. If a continuous mixing plant is to be used for mixing, the Contractor must demonstrate by laboratory analysis that cold feed combined grading is within permissible grading limits and binder content is in compliance to the specified grading and bitumen content.

Semi Dense Bituminous Concrete shall be transported in clean insulated vehicles and unless otherwise agreed by the Engineer, shall be covered while in transit or awaiting tipping. Subject to the approval of the Engineer, a bitumen release agent, such as soap or lime water may be applied to the interior of the vehicles to prevent sticking and to facilitate discharge of the material. Care shall be taken to ensure that segregation of materials does not take place.

### **509.5.4** *Spreading*

#### *509.5.4.1* *Weather and seasonal limitations*

Laying of Semi Dense Bituminous Concrete shall not be carried out when the air temperature at the surface over which it is to be laid is below 10°C or when the wind speed at any temperature exceeds 40 km/hr at 2 m height unless specifically approved by the Engineer. Laying shall be suspended while free-standing water is present on the surface to be covered, or when rain is imminent or during rain, fog and dust storms. After rain, the surface shall be left to dry before laying shall start.

#### *509.5.4.2* *Preparation of base*

The base on which Semi Dense Bituminous Concrete is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clause 501, as appropriate, depending on the site conditions, or as directed by the Engineer.

#### *509.5.4.3* *Spreading*

Except in areas where a mechanical paver cannot access, premixed Semi Dense Bituminous Concrete material shall be spread, leveled, and tamped by an approved self-propelled hydrostatic paving machine preferably fitted with sensor. The essential features of the paver shall conform to IRC:27. As soon as possible, after arrival at site, the materials shall be supplied continuously to the paver and laid without delay.

The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver and its method of operation, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space where a mechanical paver cannot be used, the material shall be spread, raked and leveled with suitable hand tools by experienced staff and compacted to the satisfaction of the Engineer.

However, in restricted locations and in narrow widths where the paver cannot be operated in the opinion of the Engineer, the material shall be spread, raked and leveled with suitable hand tools by trained staff.

### 509.5.5 *Compaction*

*509.5.5.1* Compaction shall commence as soon as possible after laying and shall be completed before the temperature falls below the minimum rolling temperatures given in **Table 500.5**. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, the rolling shall commence at the edge and progress towards the center longitudinally except at sections with unidirectional camber, where it shall progress from lower edge to upper edge parallel to center line of the pavement.

*509.5.5.2* All deficiencies in the surface after laying shall be made good by the attendant behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with the 8 to 10 tonnes dead weight or vibratory steel wheel roller. The intermediate rolling shall be done with 8 to 10 tonnes dead weight or vibratory roller or with a pneumatic roller of 12 to 15 tonnes, with a tire pressure of at least 0.56 MPa. The finished rolling shall be done with 6 to 8 tonnes smooth wheel roller. Rolling shall continue till all the roller marks are removed from the surface and the minimum specified field density is achieved.

*509.5.5.3* The Semi Dense Bituminous Concrete mixes shall be rolled in the longitudinal direction, with the roller as close as possible to the paver. The overlap on successive passes should be at least one-third of the width of the rear roll or in the case of pneumatic wheeled rollers, at least the nominal width of 300 mm. The roller should move at a speed of no more than 5 km/hour. The roller shall not be permitted to stand on pavement, which has not been fully compacted. All precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign material on the pavement. The wheel of the rollers shall be kept moist with the water or spray system provided with the machine to prevent the mixture from adhering to the wheels. Minimum moisture to prevent adhesion between wheels and mixture shall be used and surplus water shall not be allowed to stand on the partially completed pavement.

*509.5.5.4* The density of the finished paving layer shall be determined by taking 150 mm diameter cores. The density of finished paving layer shall not be less than the 92 percent of the average (sample size N=2) theoretical maximum specific gravity of the loose mix (Gmm) obtained on that day in accordance with ASTM D2041. See **Annexure-500.5** for the outline of ASTM D2041.

### 509.5.6 *Joints*

*509.5.6.1* Where joints are made, the material shall be fully compacted and the joint made flush in one of the following ways.

a) All joints shall be cut vertical to the full thickness of the previously laid mix. All loosened material shall be discarded and the vertical face be coated with any viscosity grade bitumen, or cold applied emulsified bitumen. While spreading the material along the joint, the material spread shall overlap 25 mm to 50 mm on the previously laid mix beyond the vertical face of the joint. The thickness of the loose overlap material should be approximately a quarter more than the final compacted thickness. The overlapped mix should be dragged back to the hot lane so that the roller can press the small excess into the hot side of the joint to obtain a high joint density.

b) By using two or more pavers in echelon, where this is practicable and in sufficient proximity for adjacent width to be fully compacted by continuous rolling.

*509.5.6.2* For transverse joints method a) above can apply. Transverse joints in the successive and adjoining layers should have a minimum offset of 2 m.

### 509.6 Opening to Traffic

No traffic shall be allowed on the road until the paved mat has cooled below a temperature at 60°C in its entire depth.

### 509.7 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800. For control of the quality of materials supplied and the work carried out, the relevant provisions of Section 1800 shall apply.

### 509.8 Arrangement for Traffic

During the period of construction, arrangement of traffic shall be made in accordance with the provision of Section 100.

### 509.9 Measurements for Payment

Semi Dense Bituminous Concrete shall be measured as finished work either in cubic meters, tonne or by the square meter for 25 mm thickness as detailed on the contract drawings or documents or as directed by the Engineer.

### 509.10 Rate

The contract unit rate for Semi Dense Bituminous concrete shall be payment in full carrying out all the required operations as specified in these specifications including full compensation for components listed in Clause 504.8 except that the rate shall include the provision of bitumen at 5.0 percent by weight of total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down accordingly.

## 510 SUPPLY OF STONE AGGREGATES FOR PAVEMENT COURSES

### 510.1 Scope

This Clause shall apply to the supply of stone aggregates only. The work shall consist only of collection, transportation and stacking the stone aggregates for use in pavement courses. The actual work of laying the pavement courses shall, however, be governed by the individual Clause for the actual work, given elsewhere in this Specification. The size and quantities of the aggregates to be supplied shall be so selected by the Engineer that the grading requirements set forth in the individual Clauses for the pavement courses, for which the supply is intended, are satisfied.

All the materials shall be procured from approved sources and shall conform to the physical requirements, specified in the respective Clauses for the individual items given elsewhere in this Specification.

## 510.2 Sizes of Stone Aggregates

The stone aggregates shall be designated by their nominal sizes in the Contract and shall conform to the requirements shown in **Table 500.18**.

## 510.3 Stacking

1) **Coarse Aggregates**

   Only the aggregates satisfying the Specification requirements shall be conveyed to the roadside and stacked. Each size of aggregate shall be stacked separately. Likewise, materials obtained from different quarry sources shall be stacked separately and in such a manner that there is no contamination of one source with another.

2) **Fine Aggregates : As stated in the individual relevant Clauses**

   The aggregates shall be stacked entirely clear of the roadway on even, clear hard ground, or on a platform prepared in advance for the purpose by the Contractor at his own cost and in a manner that allows correct and ready measurement. If the stockpile is placed on ground where the scraping action of the loader can contaminate the material with underlying soil, then the stockpile shall be rejected by the Engineer. Materials shall not be stacked in locations liable to inundation or flooding.

The dimensions of the stockpiles and their locations shall be approved by the Engineer. Where the material is improperly stacked, the Engineer shall direct complete re-stacking of the materials in an approved manner at the Contractor's cost.

**Table 500.18 Size Requirements for Coarse Stone Aggregates**

| Sl. No. | Nominal Size of Aggregate | Designation of Sieve Through which the Aggregates shall Wholly Pass | Designation of Sieve on which the Aggregates shall be Wholly Retained |
|---|---|---|---|
| | | | |
| i) | 75 mm | 106 mm | 63 mm |
| ii) | 63 mm | 90 mm | 53 mm |
| iii) | 45 mm | 53 mm | 26.5 mm |
| iv) | 26.5 mm | 45 mm | 22.4 mm |
| v) | 22.4 mm | 26.5 mm | 13.2 mm |
| vi) | 13.2 mm | 22.4 mm | 11.2 mm |
| vii) | 11.2 mm | 13.2 mm | 6.7 mm |
| viii) | 6.3 mm | 11.2 mm | 2.8 mm |

### 510.4 Quality Control of Materials

The Engineer shall exercise control over the quality of the materials so as to ascertain their conformity with the Specification requirements, by carrying out tests for the specified properties in accordance with Section 1800 of these specifications.

Materials shall only be brought to site from a previously tested and approved source, and any materials not conforming to the requirements of the Specification shall be rejected by the Engineer and removed from the work site.

### 510.5 Measurements for Payment

Coarse and fine aggregates supplied to the site shall be paid for in cubic metres. The actual volume of the aggregates to be paid for shall be computed after deducting the specified percentages in **Table 500.19**, from the volume computed by stack measurements, to allow for bulking.

**Table 500.19 Percent Reduction in Volume of Aggregates**

| Sl. No. | Nominal Size of Aggregates | Percentage Reduction in Volume Computed by Stack Measurements to Arrive at the Volume to be paid for |
|---|---|---|
| 1) | 75 mm and 63 mm | 12.5 |
| 2) | 45 mm and 26.5 mm | 10.0 |
| 3) | 22.4 mm, 13.2 mm, 11.2 mm and 6.3 mm | 5.0 |
| 4) | Fine aggregates | 5.0 |

Unless otherwise directed by the Engineer, measurements shall not be taken until sufficient materials for use on the road have been collected and stacked. Immediately after measurement, the stacks shall be marked by white wash or other means as directed by the Engineer.

### 510.6 Rate

The contract unit rates for different sizes of coarse and fine aggregates shall be payment in full for collecting, conveying and stacking or storing at the site including full compensation for :

a) all royalties, rents where necessary;

b) all leads and lifts;

c) all labour, tools, equipment and incidentals to complete the work to the Specifications; and

d) all necessary testing of material, both initial, to approve the source, and regular control testing thereafter.

## 511 MODIFIED BITUMEN

### 511.1 Scope

Modified bitumen comprises a base binder, to which is added either natural rubber, crumb rubber or synthetic rubber or synthetic polymer or a blend of these to achieve a high performance binder with improved properties, particularly at extremes of temperature. The modified bitumen shall comply with the requirements of these Specifications.

Any type of modified bitumen as per IS:15462 can be specified subject to the condition that the product meets the specification requirement given in **Table 500.20** of these Specifications.

### 511.2 Materials

### 511.2.1 *Base binder*

The base binder into which the modifier is incorporated shall conform to IS:73. The choice of grade shall be such that it is compatible with the modifier and, when mixed, shall have the properties described in Clause 511.3.

### 511.2.2 *Modifier*

The modifier shall be a natural rubber, crumb rubber or any other polymer which is compatible with the base binder and which allows the properties given in Clause 511.3 to be achieved. For further details, IRC:SP:53 may be referred to.

### 511.2.3 *Modified bitumen*

Modified Bitumen from refinery sources or blended at central plant using appropriate industrial process and plant as specified in IRC:SP:53 shall be used. Proprietary products where used shall comply with the requirements of these Specifications.

The manufacturer shall establish procedures to ensure that conformance to the specified characteristics are maintained. Where testing is required on each batch, a batch is considered to be the quantity of binder produced and stored in one tank once the production run into that tank has ben completed. The batch can be considered to remain the same as long as no new production has been added. The specification requirement of modified binder shall conform to IRC:SP:53 as indicated in **Table 500.20**. Modified bitumen for various climatic conditions based on highest and lowest daily mean air temperatures at site can be selected on the basis of properties given in **Table 500.20**.

### 511.3 Modified Bitumen Properties and Testing

The properties of the modified bitumen shall be as given in **Table 500.20**. The supplier shall furnish a certificate from a reputed laboratory acceptable to the Engineer for each batch stating the properties of the modified binder. The modified binder shall be subjected to the tests for quality control in accordance with Section 1800 of these Specifications before and during execution of the works.

### Table 500.20 Properties of Modified Bitumen

| | Highest Mean Air Temperature | < 20°C | 20°C to 35°C | Above 35°C | |
|---|---|---|---|---|---|
| | Lowest Mean Air Temp | >-10°C<br>< -10°C | >-10°C<br>< -10°C | >-10°C | |
| **Sl. No.** | **Characteristics** | **Specified Values for the Modified Bitumen** | | | **Method of Test. IS No.** |
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| i) | Penetration at 25°C, 0.1 mm, 100g, 5s | 60 to 120 | 50 to 80 | 30 to 50 | 1203 |
| ii) | Softening point, (R&B), °C, Min | 50 | 55 | 60 * | 1205 |
| iii) | FRAASS** breaking point, °C, Max | -20 | -16 | -12 | 9381 |
| iv) | Flash Point, COC, °C, Min | 220 | 220 | 220 | 1209 |
| v) | Elastic recovery of half thread in ductilometer at 15 °C, percent, min | 50 | 60 | 60 | |
| vi) | Complex modulus ($G^*/\sin\delta$) as Min 1.0 kPa at 10 rad/s, at a temperature, °C | 58 | 70 | 76 | |
| vii) | Separation, difference in softening point (R&B), °C, Max | 3 | 3 | 3 | |
| viii) | Viscosity at 150 °C, Poise | 1-3 | 3-6 | 5-9 | 1206 (Part 2) |
| ix) | Thin film oven test and tests on residue: | | | | |
| | a) Loss in mass, percent, Max | 1.0 | 1.0 | 1.0 | 9382 |
| | b) Increase in softening point, °C, Max | 7 | 6 | 5 | 1205 |
| | c) Reduction in penetration of residue, at 25 °C, percent, Max | 35 | 35 | 35 | 1203 |
| | d) Elastic recovery of half thread in ductilometer at 25 °C, percent, Min | 35 | 50 | 50 | - |
| | Or | | | | |
| | Complex modulus as ($G^*/\sin\delta$) as Min 2.2 kPa at 10 rad/s, at temperature °C | 58 | 70 | 76 | - |

* Where max temperature exceeds 40°C, Softening Point should be 65°C

** Fraass breaking point requirement will be applicable for areas of subzero temperatures.

### 511.4 Handling of Modified Bitumen

**511.4.1** The modified bitumen shall be transported and supplied hot. Safety and handling procedures that are applicable for hot bituminous materials also apply to modified bitumen. The modified bitumen supplied in bulk or drums shall be agitated/recirculated in hot condition with suitable device to ensure homogeneity of the products. Transportation and storage of modified bitumen shall be done as per IRC:SP:53.

**511.4.2** The temperature of mixing and rolling shall be slightly higher than conventional bituminous mixes. The broad range of viscosity and temperature at different stages is given in **Table 500.21**. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per advice of supplier or test data of viscosity of modified bitumen at different temperatures.

**Table 500.21 Broad Range of Temperature Requirements for Modified Binders**

| Stage of Work | **Indicative Temperature °C** |
|---|---|
| binder at mixing | 165-185 |
| aggregate temperature | 165-185 |
| mix at mixing plant | 150-170 |
| mix at laying site | 130-160 |
| rolling at laying site | 115-155 |

**511.4.3** Manufacturer of proprietary products shall be responsible to provide full details to user for special precautions needed for their products at site or may depute their technical personnel, if required.

### 511.5 Controls

The quality assurance in storage and handling of modified bitumen and mixes at site shall be as per IRC:SP:53.

The Specifications for various items of road works using Polymer/Rubber Modified Bitumen are the same as those for viscocity grade bitumen except those for any special conditions which the manufacturer of modified bitumen or supplier of additive may indicate in the technical literature of the product. The other controls during mixing and laying shall be the same as specified in the relevant IRC Codes of Practice.

### 511.6 Measurements for Payment

Modified binder supplied for the Contract shall be paid for in tonnes.

### 511.7 Rate

The contract rate for modified binder shall be as per contract agreement.

# 512 BITUMINOUS WEARING COURSES USING WASTE PLASTIC

## 512.1 Scope

These specifications cover the use of waste plastic in 25 mm Semi-Dense Bituminous Concrete (Clause 509), Mix Seal Surfacing (Clause 507) and 20 mm Open Graded Premix Carpet (Clause 506.1).

The work shall consist of the preparation, laying and compaction of the specified type of wearing course incorporating waste plastic using dry process in accordance with the requirements of these specifications. The type of wearing course to be provided shall be specified in the Contract.

In the dry process, the waste plastic after processing and shredding is added in hot aggregates. IRC:SP:98 shall be applicable for the use of waste plastic.

## 512.2 Materials

### 512.2.1 *Binder*

The binder shall be a viscosity grade paving bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfy the requirements of IS:73. Guidance may be taken from **Annexure-500.2** for selection of appropriate grade bitumen.

### 512.2.2 *Aggregates*

The provisions of the following Clauses shall apply:

Clauses 509.2.2 and 509.2.3 for 25 mm Semi Dense Bituminous Concrete.

Clauses 507.2.2 and 507.2.3 for Mix Seal Surfacing.

Clause 506.1.2.2 for 20 mm Open Graded Premix Carpet.

### 512.2.3 *Filler*

The provisions of Clause 509.2.4 shall apply for filler for 25 mm Semi Dense Bituminous Concrete.

### 512.2.4 *Waste plastic*

Only Thermoplastic materials conforming to Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), Polyethylene Teryphthalate (PET) and Polyurethane (PU) shall be used. The waste plastic shall conform to the following requirements:

i) Plastic waste shall be clean and shredded to size passing 2.36 mm sieve and retained on 600 micron sieve.

ii) Dust and other impurities shall not be more than 1 percent. The method to determine the quantity of impurity is to determine the ash content at 600°C.

iii) Melt- flow value tested as per ASTM D 1238-2010 shall be in the range 0.14 – 58 gm/10 min for LDPE, and .02-9.0 gm/10 min for HDPE.

### 512.3 Aggregate grading and Proportioning of Materials

### 512.3.1 *Semi Dense Bituminous Concrete (SDBC)*

Aggregate grading and bitumen content shall be as per Clause 509.3.

Quantity of waste plastic shall be 6 to 8 percent of the weight of bitumen, depending on low rainfall or high rainfall areas as specified in the Contract.

### 512.3.2 *Mix Seal Surfacing (MSS)*

Clauses 507.2.4 and 507.2.5 shall apply.

Quantity of waste plastic shall be 6 to 8 percent of the weight of the bitumen.

### 512.3.3 *20 mm Open Graded Premix Carpet (OGPC)*

Clause 506.1.2.3 shall apply.

Quantity of waste plastic shall be 6 to 8 percent of the weight of the bitumen.

### 512.4 Design of Mix for SDBC

Clause 509.4 shall apply subject to the modification that the mix shall meet the requirements indicated in **Table 500.22**.

**Table 500.22 Requirements of SDBC Mix Using Waste Plastic**

| | |
|---|---|
| Minimum stability (kN at 60°C) | 12.0 |
| Minimum flow (mm) | 2 |
| Maximum flow (mm) | 4 |
| Marshall Quotient (kN/mm) | 2.5-5 |
| Compaction level (Number of blows) | 75 blows on each of the two faces of the specimen |
| Percent air voids | 3 – 5 |
| Retained Stability (%) | 98 |
| ITS (min) MPa | 0.9 |
| VMA | 16 |
| VFB | 65-75 |

### 512.5 Process

The following process shall be adopted in preparation of the bituminous mix using plastic waste.

### 512.5.1 *Collection of waste plastic*

Waste plastic is collected from roads, garbage trucks, dump sites or compost plants or from school collection programmes or by purchase from rag-pickers or waste buyers.

### 512.5.2 *Cleaning and shredding*

Waste plastic litter in the form of thin-film carry bags, use-and-throw cups, PET bottles is sorted and dust removed. If necessary, the litter may be washed. The cleaned plastic waste is shredded using a shredding machine so that it conforms to the size passing 2.36 mm sieve and retained on 600 micron sieve.

### 512.5.3 *Mixing of shredded plastic waste, aggregate and bitumen in hot mix plant:*

The aggregate mix is heated to 140ºC -175ºC in an approved hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality. The requisite percentage of waste plastic to the weight of bitumen is injected with a pipe under compressed air in the drum of a drum mix plant through a pipe at 2/3 length of the drum or through an opening over the pug mill in the case of a batch mix plant. The waste plastic initially coats the heated aggregates. In the next stage, bitumen is added to the aggregates, the temperature of the binder shall conform to the temperature depending on the grade of binder and the type of mix. The plastic waste coated aggregate is mixed with hot bitumen for 15 seconds and the resulting mix transported for road construction.

### 512.5.4 *Laying temperature of bituminous mix*

The temperature of the mix at the time of laying shall be between 110ºC and 120ºC.

## 512.6 Construction Operations

All construction operations shall be in accordance with Clause 509.5 for SDBC, Clause 507.3 for MSS and Clause 506.1.3 for 20 mm PC.

## 512.7 Opening to Traffic

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Speed restriction may be imposed at initial stages.

## 512.8 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 1800. For control of the quality of materials supplied and the work carried out, the relevant provisions of Section 1800 shall apply. Waste plastic shall be tested for impurity and melt flow value. Three samples shall be tested for each day work or when there is change in the source of plastic.

## 512.9 Arrangements for Traffic during Construction

During the period of construction, arrangements for traffic shall be in accordance with the provisions of Section 100.

### 512.10 Measurement for Payment

The work shall be measured as specified in Clause 509.9 for SDBC, Clause 507.7 for MSS and Clause 506.1.7 for 20 mm OGPC.

### 512.11 Rate

The contract unit rate for SDBC, MSS and 20 mm OGPC shall be as specified in Clause 509.10, 507.8 and 506.1.8 respectively as applicable to the work specified in these specifications.

## Annexure–500.1

(Clause 501.6)

## PROTECTION OF THE ENVIRONMENT

### 1. General

1.1. This section of the Specification sets out limitations on the Contractor's activities specifically intended to protect the environment.

1.2. The Contractor shall take all necessary measures and precautions and otherwise ensure that the execution of the works and all associated operations on site or off-site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in this document.

1.3. The Contractor shall take all measures and precautions to avoid any nuisance or disturbance arising from the execution of the Works. This shall wherever possible be achieved by suppression of the nuisance at source rather than abatement of the nuisance once generated.

1.4. In the event of any spoil, debris, waste or any deleterious substance from the Site being deposited on any adjacent land, the Contractor shall immediately remove all such material and restore the affected area to its original state to the satisfaction of the Engineer.

### 2. Water Quality

2.1. The Contractor shall prevent any interference with the supply to or abstraction from, and prevent any pollution of, water resources (including underground percolating water) as a result of the execution of the works.

2.2. Areas where water is regularly or repetitively used for dust suppression purposes shall be laid to fall to specially-constructed settlement tanks to permit sedimentation of particulate matter. After settlement, the water may be re-used for dust suppression and rinsing.

2.3. All water and other liquid waste products arising on the Site shall be collected and disposed of at a location on or off the Site and in a manner that shall not cause either nuisance or pollution.

2.4. The Contractor shall not discharge or deposit any matter arising from the execution of the Works into any waters except with the permission of the Engineer and the regulatory authorities concerned.

2.5. The Contractor shall at all times ensure that all existing stream courses and drains within, and adjacent to, the Site are kept safe and free from any debris and any materials arising from the Works.

2.6. The Contractor shall protect all watercourses, waterways, ditches, canals, drains, lakes and the like from pollution as a result of the execution of the Works.

## 3. Air Quality

3.1. The Contractor shall devise and arrange methods of working to minimise dust, gaseous or other air-borne emissions and carry out the Works in such a manner as to minimise adverse impacts on air quality.

3.2. The Contractor shall utilise effective water sprays during delivery manufacture, processing and handling of materials when dust is likely to be created, and to dampen stored materials during dry and windy weather. Stockpiles of friable materials or debris shall be dampened prior to their movement, except where this is contrary to the specification.

3.3. Any vehicle with an open load-carrying area used for transporting potentially dust producing material shall have properly fitting side and tail boards. Materials having the potential to produce dust shall not be loaded to a level higher than the side and tail boards and shall be covered with a clean tarpaulin in good condition. The tarpaulin shall be properly secured and extend at least 300 mm over the edges of the side and tail boards.

3.4. In the event that the Contractor is permitted to use gravel or earth roads for haulage, he shall provide suitable measures for dust palliation, if these are, in the opinion of the Engineer, necessary. Such measures may include spraying the road surface with water at regular intervals

## 4. Noise

4.1. The Contractor shall consider noise as an environmental constraint in his planning and execution of the works.

4.2. The Contractor shall take all necessary measures so that the operation of all mechanical equipment and construction processes on and off the Site shall not cause any unnecessary or excessive noise, taking into account applicable environment requirements. The Contractor shall use all necessary measures and shall maintain all plant and silencing equipment in good condition so as to minimise the noise emission during construction works.

## 5. Control of Wastes

5.1. The Contractor shall control the disposal of all forms of waste generated by the construction operations and in all associated activities. No uncontrolled deposition or dumping shall be permitted. Wastes to be controlled shall include, but shall not be limited to, all forms of fuel and engine oils, all types of bitumen, cement, surplus aggregates, gravels, bituminous mixtures, etc. The Contractor shall make specific provision for the proper disposal of these and any other waste products, conforming to local regulations and acceptable to the Engineer.

## 6. Emergency Response

6.1. The Contractor shall plan and provide for remedial measures to be implemented in the event of occurrence of emergencies such as spillages of oil or bitumen or chemicals.

6.2. The Contractor shall provide the Engineer with a statement of the measures he intends to implement in the event of such an emergency which shall include a statement of how he intends to provide personnel adequately trained to implement such measures.

## 7. Measurement

7.1. No separate measurement shall be made in respect of compliance by the Contractor with the provisions of this section of the Specifications. The Contractor shall be deemed to have made allowance for such compliance with these provisions in the preparation of his prices for items of work included in the Bills of Quantities and full compensation for such compliance will be deemed to be covered by them.

## Annexure–500.2

(Clause 504.2)

### SELECTION CRITERIA FOR VISCOCITY GRADED (VG) PAVING BITUMEN BASED ON CLIMATIC CONDITIONS

| **Lowest Daily Mean Air Temperature, °C** | **Highest Daily Mean Air Temperature °C** | | |
|---|---|---|---|
| | Less than 20°C | 20 to 30°C | More than 30°C |
| More than -10°C | VG-10 | VG-20 | VG-30 |
| -10°C or lower | VG-10 | VG-10 | VG-20 |

## Annexure–500.3

(Clause 507.2.1)

### RECOMMENDED NOMINAL SIZES OF STONE CHIPPINGS (MILLIMETRES)

| **Type of Surface** | **Approximate Number of Commercial Vehicles with a Laden weight Greater than 3.0 tonnes Currently Carried per day in the Lane Under Consideration** | | |
|---|---|---|---|
| | **200-1000** | **20-200** | **Less than 20** |
| Very Hard | 6 | 6 | 6 |
| Hard | 10 | 6 | 6 |
| Normal | 10 | 10 | 6 |
| Soft | 13 | 13 | 10 |
| Very soft | 19 | 13 | 10 |

***Note :*** The size of stone chippings is related to the mid-point of each lane traffic category. Light traffic conditions may make the next smaller size of stone more appropriate.

The assessment of hardness of the existing road surface shall be made on the basis of judgment with the help of the definitions given below :

| **Category of Surface** | **Definition** |
|---|---|
| Very Hard | Surfaces, such as concrete, or very lean bituminous structures with dry stony surfaces, into which negligible penetration of chippings will occur even under the heaviest traffic. |
| Hard | Surfaces into which chippings will penetrate only slightly under heavy traffic. |
| Normal | Surfaces into which chippings will penetrate moderately under medium and heavy traffic. |

| | |
|---|---|
| Soft | Surfaces into which chippings will penetrate considerably under medium and heavy traffic. |
| *Very soft* | *Surfaces usually rich in binder, into which even large aggregates will be submerged under heavy traffic.* |

In selecting the nominal size of chipping for two-coat surface dressings, the size of chippings for the first layer shall be selected on the basis of the hardness of the existing surface and the traffic category as indicated above. The nominal size of chipping selected for the second layer shall then be about half the nominal size of that of the first layer to promote good interlock between the layers.

## Annexure–500.4

(Clause 509.2.4.2)

## OUTLINE OF AASHTO T283, "RESISTANCE OF COMPACTED ASPHALT MIXTURES TO MOISTURE-INDUCED DAMAGE"

### A. Scope and Summary of Test Method

This method covers preparation of compacted bituminous mixtures and the measurement of the change of diametral tensile strength resulting from the effects of water saturation and laboratory accelerated stripping phenomenon with a freeze-thaw cycle. The result may be used to predict long-term stripping susceptibility of bituminous mixtures and evaluate liquid anti-stripping additives that are added to bitumen or pulverized mineral materials such as hydrated lime, which are added to be mineral aggregate.

Each set of 6 compacted specimens is divided into two equal subsets. One subset is tested in dry condition for indirect tensile strength. The other subset is subjected to vacuum saturation and a freeze-thaw cycle (thawing in a hot water bath) before testing for indirect tensile strength. Numerical indices of retained indirect tensile strength properties are calculated from the test data obtained by testing the two subsets: dry and conditioned.

### B. Testing Equipment

1) Vacuum container, vacuum pump, manometer, and other accessories as specified in ASTM D2041, "Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures".

2) Balance or scale accurate to 0.1 percent of the test load

3) Two water baths capable of maintaining temperatures of 60°C ± 1°C and 25°C ± 0.5°C.

4) Freezer maintained at - 18°C ± 3°C

5) 10-ml graduate cylinder

6) Loading jack and ring dynamometer (Marshall stability testing machine can be used) to provide a vertical rate of deformation of 50 mm (2 inches) per minute and capable of reading the maximum failure load

7) Steel loading strips with a concave surface having a radius equal to the normal radius of the test specimen. The loading strips shall be 12.7 mm (0.5 inch) wide for specimens 100 mm (4 inches) in diameter. The loading strips for 150 mm (6 inches) diameter specimens shall be 19.05 mm (0.75 inch) wide. The length of the loading strips shall exceed the thickness of the specimens. Steel strip provided at the top and bottom of specimens during indirect tensile testing.

### C. Test Procedure

1) Make at least 6 compacted specimens for each mixture, 3 to be tested dry and 3 to be tested after partial saturation and moisture conditioning with a freeze-thaw cycle. Some extra specimens will need to be made to establish compaction procedures in order to obtain specified air void contents in the test specimens by trial and error.

2) Compact the 6 specimens with a Marshall compactor so that the compacted specimens have air voids of 7.0 ± 0.5 percent. This level of high air voids can be obtained by adjusting the number of Marshall blows applied on each side of the specimen by trial and error (start at about 10 blows as a starting point). Air void content must be calculated from the bulk specific gravity of the compacted specimen (determined by saturated surface dry method as per procedure given in the Asphalt Institute MS-2) and the maximum theoretical specific gravity of the loose bituminous mixture obtained by ASTM D2041.

3) Separate the 6 specimens into 2 subsets so that the average air voids of the two subsets are approximately equal.

4) One set will be tested dry. Keep it at room temperature and then place in a 25ºC ± 0.5ºC water bath for 2 hours prior to determining their indirect tensile strength.

5) The other subset will be conditioned as follows:

   a) Place and submerge the 3 specimens in the vacuum container filled with water at room temperature. Apply a vacuum of 13-67 kPa absolute pressure (10-26 inches Hg partial pressure) for 30 minutes. Remove the vacuum and leave the specimens submerged in water for 5 to 10 minutes. [Note: The water saturation procedure noted above deviates from AASHTO T283, which obtains a specified degree of saturation. The above procedure keeps the time of saturation constant.]

   b) Wrap a plastic film around each saturated specimen and place the wrapped specimen in a plastic bag containing 10 ml of water and seal the plastic bag. Place the plastic bag in a freezer at temperature of -18ºC ± 3ºC for a minimum of 16 hours. Remove the specimens from the freezer.

   c) Place the specimens in a water bath maintained at 60ºC ± 1ºC for 24 hours. Remove the plastic bag and the plastic film from each specimen after placing the specimens under water.

   d) Remove the specimens from hot water bath and place in a water bath maintained at 25ºC ± 0.5ºC for 2 hours.

   e) Remove the conditioned specimens and test for indirect tensile strength.

6) Determine the indirect tensile strength of the 3 dry and 3 conditioned specimens at 25°C ± 0.5°C after removing from water bath. First, measure their mean thickness (t). Then place the two steel loading strips on the bottom and top of the specimens across diameter and place in the Marshall testing machine or a compression-testing machine. Apply load to the specimens diametrally at a vertical rate of 50 mm (2 inches) per minute.

7) Record the maximum compressive strength noted on the testing machine and continue loading until a vertical crack appears in the specimen. Remove the cracked specimen from the machine and visually estimate the approximate degree of moisture damage (extent of stripped or bare aggregate) on the fractured faces of the specimen on a scale of 0 to 5 (5 being the most stripping).

8) Calculate the tensile strength of each specimen as follows in SI units:

$$St = 2000\,P / \pi\, t\, d$$

where,

St = tensile strength, kPa

P = maximum loads, N

t = specimen thickness, mm

d = specimen diameter, mm

9) Express the numerical index of resistance of bituminous mixture to the detrimental effects of water as the ratio of the original strength that is retained after accelerated moisture and freeze-thaw conditioning.

Calculate the Tensile Strength Ratio (TSR) as follows:

$$\text{Tensile strength ratio (TSR)} = S_2 / S_1$$

where,

$S_1$ =average tensile strength of the dry subset, kPa

$S_2$ =average tensile strength of the conditioned subset, kPa

## Annexure–500.5

(Clause 509.4.5.2 & 509.5.5.4)

# OUTLINE OF ASTM D2041, "THEORETICAL MAXIMUM SPECIFIC GRAVITY AND DENSITY OF BITUMINOUS PAVING MIXTURES"

## A. Scope and Summary of the Test Method

This test method covers the determination of the theoretical maximum specific gravity and density of uncompacted bituminous paving mixtures at 25°C. The theoretical maximum specific gravity (Gmm) is used: (a) to calculate air voids in compacted bituminous mixtures, (b) to calculate the amount of bitumen absorbed by the aggregate, and (c) to provide target value for the compaction of paving mixtures in the field.

A sample of loose paving mixture is placed in a tared vacuum vessel. Water at 25°C is added to completely submerge the sample. A specific amount of vacuum is gradually applied to remove the air bubbles entrapped between asphalt mix particles. After the vacuum is released, the volume of the sample of the voidless paving mixture is obtained by either immersing the vacuum container with the sample in a water bath and weighing or by filling the calibrated vacuum container level full of water and weighing in air.

## B. Testing Equipment

1) Container (either a or b below)

   a) **Vacuum bowls –** Either a metal or plastic bowl with a diameter ranging from 180 to 260 mm and a bowl height of at least 160 mm. The bowl shall be equipped with a stiff, transparent cover fitted with a rubber gasket and a connection for the vacuum line. The hose connection shall be covered with a small piece of fine wire mesh to minimize loss of any fine material from the mix.

   b) **Vacuum flask for weighing in air only –** A thick-walled volumetric glass flask with a capacity of approx. 4000 ml, fitted with a rubber stopper with a connection for the vacuum line. The hose connection shall be covered with a small piece of fine wire mesh to minimize loss of any fine material from the mix.

2) Balance capable of being read to the nearest 0.1 gram. If weighing is to be done under water, a suitable suspension arrangement shall be provided for weighing the sample while suspended from the center of the balance.

3) Vacuum pump, capable of evacuating air from the vacuum container to a residual pressure of 4.0 kPa (30 mm of Hg) or less. Provide a suitable trap between the pump and container to minimize water vapour entering the vacuum pump.

4) Residual pressure manometer or calibrated absolute pressure gauge with a bleed valve to adjust the vacuum level.

5) Water bath capable of maintaining a constant temperature of 25 ± 1°C and suitable for immersion of the suspended container.

### C. Calibration of Containers

1) **Bowls –** Determine the mass (B) of the container immersed in water at 25 ± 1°C. If the bowl is used for weighing in air, place the volumetric lid on the bowl while under water. Remove the water-filled bowl with the lid in place and dry prior to determining the combined mass of the bowl, lid and water. Repeat 3 times and average the 3 masses. Designate the average mass as D.

2) **Flasks –** Calibrate the volumetric flask by accurately determining the mass of the flask filled with water at 25 ± 1°C. Use a glass cover plate to ensure the flask is completely full.

### D. Test Procedure

1) Separate the particles of the loose paving mixture (while it is warm) by hand so that the particles are not larger than about 6 mm. Don't fracture the aggregate. Place the mix sample directly into the tared bowl or flask. Weigh the container with the sample and designate the net mass of the sample only as A. [Note: The minimum sample size shall be 1500g for mixes with nominal maximum aggregate sizes of 12.5 mm or smaller; and shall be 2500g for mixes with nominal maximum aggregate sizes from 19 to 25 mm.]

2) Add sufficient water at 25°C to cover the sample completely. Place the cover (bowls) or stopper (flasks) on the containers.

3) Place the container with the sample and water on a mechanical agitation device or agitate manually at frequent intervals (2 to 3 minutes). Begin removing entrapped air by gradually applying vacuum and increasing the vacuum pressure until the residual manometer reads 3.7 ± 0.3 kPa (25 ± 2.5 mm of Hg). After achieving this level within 2 minutes, continue the vacuum and agitation for 15 ± 2 minutes. Gradually release the vacuum with the bleed valve.

4) Weighing in water – Suspend the bowl (without lid) and contents in water for 10 ± 1 minutes and then determine mass. Designate the mass under water of the bowl and sample as C.

5) Weighing in air

   a) Bowl – Submerge the bowl and sample slowly in the 25 ± 1°C water bath. Keep it there for 10 ± 1 minutes. Immerse the lid in water and slide it onto the bowl without removing water from the bowl so that no air is trapped inside the bowl. Remove the bowl with the lid in place from the water bath. Dry the bowl and lid with a dry cloth. Determine the mass of the bowl, sample and lid and designate it as E.

b) Flask – Fill the flask slowly with water ensuring not to introduce any air into the sample. Place the flask in water bath for 10 ± 1 minutes to stabilize the temperature at 25°C without submerging the top of the flask. Completely fill the flask with water using a cover plate without entrapping air beneath the cover plate. Wipe the exterior of the flask and cover plate. Determine the mass of the flask, plate and its contents completely filled with water. Designate this mass as E.

6) Calculations

Calculate the maximum specific gravity of the sample of loose paving mixture as follows:

**a) Bowls Used Under Water Determination:**

$$G_{mm} = A / [A-(C-B)]$$

where,

$G_{mm}$ = maximum specific gravity of the mixture

A = mass of the dry sample in air, g

B = mass of bowl under water, g

C = mass of bowl and sample under water, g

**b) Bowls in Air Determination:**

$$G_{mm} = A / (A+D-E)$$

where,

$G_{mm}$ = maximum specific gravity of the mixture

A = mass of dry sample in air, g

D = mass of lid and bowl with water at 25°C, g

E = mass of lid, bowl sample and water at 25°C, g

**C) Flask Determination:**

$$G_{mm} = A / (A+D-E)$$

where,

$G_{mm}$ = maximum specific gravity of the mixture

A = mass of dry sample in air, g

D = mass of cover plate and flask filled with water at 25°C, g

E = mass of flask, cover plate, sample, and water at 25°C, g

# 600

# BRICK MASONRY FOR STRUCTURES

## 601 SCOPE

The work shall consist of construction of structures with bricks jointed together by cement mortar or cement-lime mortar in specified proportions in accordance with the provisions laid down in this Section, IRC:40 and details shown on the drawings or as approved by the Engineer.

## 602 MATERIALS

All materials to be used in the work shall conform to the requirements of Section 2000 of these Specifications.

## 603 MORTAR

Mortar in general shall conform to IS:2250 and shall be mixed in the specified proportions given on the drawings. The mix shall be clean and free from materials, like acids, alkali, organic matter or other deleterious substances.

For cement mortar, cement shall be proportioned only by weight, taking cement bag weighing 50 kg as 0.035 cum (unit weight as 1.44 tonne per cum) and other ingredients shall be proportioned by weight and converted into volume boxes. Based on the requirements at site, box size corresponding to one cement bag or half bag shall be adopted to avoid any error in proportioning. Sand shall be measured after making due allowance for bulking. Inner dimensions of box may be 300 mm x 300 mm x 390 mm corresponding to one cement bag or 300 mm x 300 mm x 200 mm corresponding to half bag of cement.

All mortar shall be mixed with a minimum quantity of water to produce desired workability consistent with maximum density of mortar. The mixing shall preferably be done in a mechanical mixer operated manually or by power. Hand mixing of mortar, can be resorted to, with the specific permission by Engineer. Hand mixing operation shall be carried out on a clean water tight platform. The ingredients in specified proportions shall be first mixed dry by being turned over and over, backwards and forwards, several times till a mix of uniform colour is obtained. Thereafter, minimum quantity of water shall be added to bring the mortar to the consistency of a workable stiff paste. The mortar shall be mixed for at least two minutes after addition of water.

For cement-lime mortar, cement, lime and sand shall be mixed in specified proportions. Cement, lime and sand shall be taken by weight by using volume boxes of suitable sizes.

Lime in ground form and sand shall thoroughly be mixed before mixing the same with cement. Immediately before use, specified proportion of cement shall be added to a small quantity of mortar and thoroughly mixed to achieve uniform distribution of cement.

Mortar shall be mixed in such quantity as required for immediate use. As a general guide, not more than half bag of cement shall be mixed at a time if one mason is engaged at site and not more than one bag of cement in case two masons are engaged. The mix which has developed initial set shall not be used in the works. In case the mortar has stiffened during initial setting time because of evaporation of water, the same shall be re-tempered by adding water as frequently as needed to restore the requisite consistency but this re-tempering shall not be permitted after 30 minutes of mixing.

The cement mortar unused for more than 30 minutes after addition of water shall be rejected and removed from site.

Cement mortar gauged with lime shall be used within two hours of mixing of lime and within 30 minutes of mixing of cement.

Necessary tests to determine compressive strength of the mortar, consistency of the mortar and its water retentivity shall be carried out in accordance with IS:2250. The frequency of testing shall be one cube for every 2 cum of mortar prepared subject to a minimum of 3 cubes for a day's work.

The masonry work shall be in cement mortar or cement-lime mortar as specified in the drawings.

## 604 SOAKING OF BRICKS

All bricks shall be thoroughly soaked in water for a minimum period of one hour before use. Soaked bricks shall be removed from the tank sufficiently in advance so that they are skin dry at the time of actual laying. Such soaked bricks shall be stacked on a clean place where these are not in contact with dirt, earth, etc.

## 605 LAYING OF BRICKS

All brickwork shall be laid in English Bond, even and true to line, in accordance with the drawing or as directed by the Engineer, plumb or specified batter and level. All joints shall be accurately laid. Vertical joints in alternate courses shall come directly one over the other. The bricks used on the face and all angles forming the junction of any two walls shall be whole bricks of uniform size and rectangular faces. Brickbats or cut bricks shall not be used except to obtain dimensions of different courses for specified bond or shape.

All bricks shall be laid with frogs up, if any, on a full bed of mortar. In case of top layer without proper coping, the frogs shall be filled with mortar before placing the bricks with frogs down in position. When laying, bricks shall be slightly pressed so that the mortar gets into all the surface pores of bricks to ensure proper adhesion. All head and side joints shall be completely filled by applying sufficient mortar to bricks already in place and on bricks to be placed. All joints shall be properly flushed and packed with mortar so that no hollow spaces are left.

The brickwork shall be built in uniform layers. Corners and other advanced work shall be raked back. Brick work shall be done true to plumb or in specified batter. During construction, no part of brick work shall rise more than one metre above the general construction level, to avoid unequal settlement and improper jointing. Where this is not possible, the work shall be raked back accordingly to the bond (and not toothed) at an angle not steeper than 45 degrees with prior approval of Engineer. Toothing may be permitted as an alternative to raking back in case future extension is contemplated.

The masonry work shall not be started earlier than 48 hours of casting of foundation block. Before laying bricks in foundation over foundation block, the top surface of the foundation block shall be thoroughly hacked, cleaned, wetted and a layer of not less than 12 mm of mortar shall be spread to prepare the surface on which the bricks will be laid. Immediately thereafter, the first course of bricks shall be laid. In case of masonry works resting on rock, the surface of the rock shall be thoroughly cleaned and levelling course of concrete of M10 grade with minimum average thickness of 150 mm shall be provided before putting the layer of mortar.

## 606 BRICK MASONRY ARCH

Brick masonry arch bridges having span more than 6 m shall not be constructed in seismic zones IV and V. Construction of brick masonry in arches wherever permitted shall in general conform to IS:2118. A full scale shape of arch shall be laid on a levelled platform near the construction site and size of brick and mortar thickness marked. Alternate brick shall be placed length wise and width wise in outer rings of arch. Remaining bricks in the inner part of the arch shall be placed to have uniform length. The courses shall be as shown in the drawings. Beds shall be properly adjusted to bring them to radial planes. Radial joints shall be in planes parallel to the transverse axis of the arch. The intrados face shall be dressed sufficiently to permit the bricks to rest properly on the centering. The bricks of the spandrel wall at their junctions with the extrados of the arch shall be cut to fit in the curvature of the arch.

Laying of arches shall commence from both ends towards the crown and the work shall be carried out systematically about the crown. Bricks shall be laid in full mortar beds with tightly filled joints. Each brick shall be first fitted dry before it is finally laid into mortar and fixed in its bed.

The masonry work shall be done in not leaner than 1:4 cement mortar. Flyash bricks can be permitted in place of burnt bricks provided their crushing strength is not less than the value specified on the drawings.

## 607 JOINTS

The thickness of joints shall not exceed 10 mm. All joints on exposed faces shall be tooled to give concave finish. In the case of arches, the thickness of joints shall not be less than 5 mm and shall not be more than 15 mm.

## 608 JOINTING OLD AND NEW MASONRY WORK

When fresh masonry is to be placed against masonry that is partially or entirely set or existing surface of structure, the exposed joining surface of the set masonry shall be cleaned of all loose material, roughened and wetted with cement slurry as directed by the Engineer so as to effect the best possible bond with the new work.

In case of vertical and inclined joints, the proper bond shall be obtained by interlocking the bricks. Any portion of the brickwork that has been completed shall remain undisturbed until thoroughly set. In case of sharp corners, a flat cutback of 100 mm shall be provided so as to have proper and bonded laying of bricks.

## 609 CURING

All brickwork shall be properly marked indicating the date of construction for keeping a watch for proper curing. Green work shall be protected from rain by suitable covering. Masonry work in cement mortar shall be kept constantly moist on all faces for a minimum period of seven days. The top of the masonry work shall be left flooded with water at the close of the day. Watering may be done carefully so as not to disturb or wash out the green mortar. In case of cement-lime mortar, curing shall commence two days after laying of masonry and shall continue for seven days.

During hot weather, all finished or partly completed work shall be covered or wetted in such a manner as to prevent rapid drying of brick work. Watering and curing shall be maintained at the close of the day's work or for other period of cessation of works. The work with mortar which has become dry, white or powdery due to neglect of curing shall be pulled down and rebuilt as directed by the Engineer. If any stain appears on the surface during watering, the same shall be removed.

## 610 SCAFFOLDING

The scaffolding shall be sound, and safe to withstand all dead, live and impact loads likely to come upon it. The scaffolding shall be provided to allow easy approach to each part of the work.

Where plastering, pointing or any other finishing has been indicated for the brick work, single scaffolding shall be provided unless otherwise specified. In single scaffolding, one end of the put-logs/pole shall rest in the hole provided in the header course of brick masonry. Not more than one header for each put-log/pole shall be left out. Such holes shall not be allowed in masonry under one metre in width or immediately near the skew backs of arches. The holes left in the masonry work for supporting the scaffolding shall be filled and made good by brick work and surface finishing as specified.

Where the brick work is to be exposed and not to be finished with plastering etc. double scaffolding having two independent supports, clear of the work, shall be provided.

The Contractor shall get the scaffolding approved from the Engineer. However, the approval by the Engineer shall not relieve the Contractor from the responsibility for its safety.

## 611 CENTERING

The centering required for proper implementation of arch work shall conform to the requirements specified in these specifications and IRC:87. The centering of arches resting on soils shall be preloaded with full designed dead load and observed for minimum 24 hours before its approval. The Contractor shall get the design, procedure for erection, stripping and other construction details approved from the Engineer. The approval by the Engineer shall however, not relieve the Contractor from the responsibility for its safety.

Wedges shall be struck in pairs from the crown outwards to the springing line loosening them gradually without shock to the arch. Not more than half the wedges shall be removed in seven days and centering shall not be struck before filling the haunch portions to half the rise in case of circular arch and 1/3 rise in segmental arch but not before 21 days of completing the masonry work. In case of multiple arch spans, centering shall not be struck and stripped before the construction of adjoining arch. However, it is preferable to keep one or two arches undisturbed between the arch last built and the arch being stripped off.

All the formwork shall be cleaned and made good as directed by the Engineer before reuse.

## 612 CONDITION OF EQUIPMENT

All equipment used for mixing or containers used for transporting mortar and bricks shall be clean and free from set mortar, dirt or other injurious foreign substances.

## 613 FINISHING OF SURFACES

### 613.1 General

All brick work shall be finished in a workmanlike manner with the thickness of joints and manner of striking or tooling as described in these specifications or as shown on the drawings.

The surfaces shall be finished by 'jointing' or 'pointing' or by 'plastering', as shown on the drawings.

For a surface which is to be subsequently plastered or pointed, the joints shall be squarely raked out to a depth of 15 mm, while the mortar is still green. The raked joints shall be wire brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted.

The mortar for finishing shall be prepared as per Clause 603.

### 613.2 Jointing

In jointing, the face of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work. The faces of brick work shall be cleaned to remove any splashes of mortar during the course of raising the brick work.

### 613.3 Pointing

Pointing shall be carried out using mortar of proportion shown on the drawings but not leaner than 1:3 by volume of cement and sand. The mortar shall be filled and pressed in to the raked out joints before giving the required finish. The pointing shall be finished to proper type given on the drawings. If type of pointing is not mentioned on the drawings, the same shall be ruled pointing. For ruled pointing, after the mortar has been filled and pressed into the joints and finished off level with the edges of the bricks, it shall, while still green, be ruled along the centre with a half round tool of suitable width or as specified by the Engineer. The superfluous mortar shall then be taken off from the edges of the lines and the surface of masonry shall be cleaned of all mortar. The work shall conform to IS:2212. Raised pointing which projects beyond the face of the brickwork shall not be used.

### 613.4 Plastering

Plastering shall be done only when it is shown on the drawings. Plastering shall be carried out using mortar of proportion shown on the drawings but not leaner than 1:4 by volume of cement and sand. Superficial plastering may be done, if necessary, only in structures situated in fast flowing channels or in severely aggressive environment. Plastering shall be started from top and worked down. All putlog holes shall be filled and made good by brick work in advance of the plastering while the scaffolding is being taken down. Wooden screeds 75 mm wide and of thickness equal to that of the plaster, shall be fixed vertically 2.5 m to 4 m apart to act as gauges and guides in applying the plaster. Before laying of plaster, the surface of brickwork shall be wetted. The mortar shall be laid on the wall between the screeds using the plaster's float and pressing the mortar so that the raked joints are properly filled. The plaster shall then be finished off with a wooden straight edge reaching across the screeds. The straight edge shall be worked on the screeds with a small upward and sideways motion 50 mm or 75 mm at a time. Finally, the surface shall be finished off with a plaster's wooden float. Metal floats shall not be used.

When recommencing the plastering beyond the work suspended a week earlier, the edges of the old plaster shall be scraped, cleaned, and wetted before new plaster is applied to the adjacent areas.

No portion of the surface shall be left unfinished for patching up at a later period.

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as directed by the Engineer.

The average thickness of plaster shall not be less than the specified thickness. The minimum thickness over any portion of the surface shall not be less that the specified thickness by more than 3 mm.

Any cracks which appear in the surface and all portions, which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and re-done as directed by the Engineer.

### 613.5 Curing of Finishes

All plastered work shall have the date of plastering marked on it for keeping a watch for proper curing. Curing shall be started as soon as the mortar of pointing/plastering has hardened sufficiently so as not to be damaged during curing. It shall be kept wet for a period of at least seven days. During this period, it shall be suitably protected from all damages. Any surface with mortar which has become dry, white or powdery due to neglect of curing shall be removed and rebuilt as directed by the Engineer. Any stain appearing during watering of surface shall be removed.

### 613.6 Scaffolding for Finishes

Provisions of Clause 610 of these Specifications shall be followed.

## 614 WEEP HOLES

Weep holes shall be provided as per Section 1200 of these Specifications.

## 615 ARCHITECTURAL COPING FOR WING/RETURN/PARAPET WALLS

This work shall consist of providing an architectural coping over the top of wing/return/parapet walls as per the drawings.

The material used shall be cement mortar 1:3 or as shown on the drawings, prepared in accordance with Clause 603.

The cement mortar shall be laid evenly to an average thickness of 15 mm to the full width of the top of the wall and in a band of 150 mm depth along the top outer face of the walls.

## 616 TOLERANCES, TESTS AND STANDARDS OF ACCEPTANCE

All work shall be done true to the lines and levels as shown on the drawings or as directed by the Engineer subject to the tolerances as indicated in these Specifications for different components of the structure.

All materials shall be tested in accordance with stipulations given in Section 2000 of these Specifications.

Sampling and testing of bricks shall be done in accordance with IS:5454 and IS:3495. The permissible values of tolerances are given below:

i) Dimensions : Variation of ± 5 percent in size.
ii) Compressive Strength of any individual brick for burnt clay/clay flyash bricks with respect to the value specified in the drawings or 8.4 MPa whichever is more. No minus tolerance shall be permitted.
iii) Water absorption : Upto 20 percent by weight when tested in accordance with IS:3495 (Part 2).
iv) Efflorescence : 'Moderate' upto 50 percent of exposed area of the brick covered with a thin deposit of salt but unaccompanied by powdering or flaking of surface when tested in accordance with IS:3495 (Part 3)

Mortar cubes shall be tested in accordance with IS:2250 for compressive strength, consistency and its water retentivity. The frequency of testing shall be one cube for every 2 cum of mortar prepared subject to a minimum of 3 cubes for a day's work.

In case of plaster finish, the surface thickness shall not be less than the specified thickness by more than 3 mm.

Section 1800 shall also apply for tests on brick work.

## 617 MEASUREMENTS FOR PAYMENT

All brick work shall be measured in cubic metres. Any extra work done by the Contractor over the specified dimensions shall be ignored and not measured.

In arches, the length of arch shall be measured as the mean length between the extrados and intrados.

The work of plastering and pointing shall be measured in sqm of the surface treated.

Architectural coping shall be measured in linear metres.

## 618 RATE

The contract unit rate for brick work shall include the cost of all labour, materials, tools and plant, scaffolding including centering if required and other expenses incidental to the satisfactory completion of the work, sampling, testing and supervision as described in these Specifications.

The contract unit rate for plastering shall include the cost of all labour, materials, tools and plant, scaffolding including centering if required and all incidental expenses, sampling and testing and supervision as described in these Specifications.

The contract unit rate for pointing shall include the cost of all labour, materials, tools and plant for erection and removal of scaffolding including centering if required and all incidental expenses to complete the pointing, i.e., raking out joints, cleaning, wetting, filling with mortar, trowelling, pointing and watering, sampling and testing and supervision as described in these Specifications.

The contract unit rate for architectural coping shall include cost of all labour, materials, tools and plant, all individual expenses, sampling and testing and supervision as described in these Specifications.

# 700

# STONE AND CONCRETE BLOCK MASONRY FOR STRUCTURES

## 701 SCOPE

The work shall consist of construction of structures with stones and concrete blocks jointed together by cement mortar or cement-lime mortar in specified proportions in accordance with the provisions laid down in this Section, IRC:40 and details shown on the drawings or as approved by the Engineer.

## 702 MATERIALS

### 702.1 General

All materials to be used in the work shall conform to the requirements of Section 2000 of these Specifications.

### 702.2 Mortar

Mortar used shall conform to Section 600 of these Specifications except that the stone masonry work shall be in cement mortar not leaner than 1:5 above bed/ground level and 1:4 below bed/ground level.

## 703 TYPE OF MASONRY

Randon rubble masonry can be used in case of return/wing/toe walls of height upto 5 m. In all other components, coursed rubble masonry (first or seconds sort) or concrete block masonry shall only be used. The type of masonry to be used for different structural members shall be specified in the drawings.

## 704 CONSTRUCTION OPERATIONS

### 704.1 General Requirements

The dressing of stone shall be as specified for individual type of masonry work and it shall also conform to the requirements of IS:1597 and requirements for dressing of stones covered in IS:1129.

### 704.2 Laying

The masonry work shall be laid to lines, levels, dimensions as shown on the drawings. The height of each course shall be kept the same and every stone shall be fine tooled on all bed joints and faces full and true. It shall be carried up true to plumb or to specified batter.

Stones shall be sufficiently wetted before laying to prevent absorption of water from mortar.

Stratified stones shall be laid on their natural beds. All bed joints shall be normal to the pressure upon them.

Outer layer of masonry shall be laid first. Location of headers (bond stones) shall then be fixed and headers laid.

Stones in the hearting shall be laid on their broadest face for a better opportunity to fill the spaces between stones and each stone fixed in mortar.

Based on locally available size of stones of any dimension not less than 150 mm, the height of course of masonry shall be predetermined by the Engineer. They shall be of same height. The height of the course shall not be less than 160 mm. When there is to be variation in the height of courses, the larger courses shall be placed at lower levels with heights of courses decreasing gradually towards the top of the wall. Mortar shall be mixed thoroughly and the fluid mortar poured in the joints. Pouring of water on dry mortar on the course to fill the gaps between stones shall not be permitted. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with mortar.

In tapered walls, the beds of the stones and the plans of courses shall be at right angle to the batter. In case of piers with batter on both sides, the courses shall be horizontal.

The bed of masonry which is to receive the stone shall be cleaned, wetted and covered with layer of fresh mortar. All stones shall be laid full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet immediately on placement and solidly embedded in mortar before it has set. Clean chips and spalls shall be wedged into the mortar joints and beds wherever necessary to avoid thick beds or joints of mortar. The quantity of mortar consumed shall be 0.25 to 0.30 cum per cubic metre of stone masonry. The face stones shall be first fixed in position and then the stones in the hearting shall be placed and fixed in the mortar. Thereafter, all interstices shall be filled with stone chips laid in mortar.

Face works and hearting shall be brought up evenly but the top of each course shall not be levelled up by the use of flat chips.

Projections of any footing course or back of abutments/return/wing wall shall not exceed the half of the depth of the course.

Foundation masonry shall not be laid directly on rock. Concrete leveling course of minimum average thickness of 150 mm and of M10 grade shall be provided on the rock before laying the first course of stone masonry. The face stones of the first course shall be dressed to fit into rock snugly when pressed down in the mortar bedding of minimum thickness of 12 mm over the leveling course. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with mortar. Annular gap around the foundations shall be filled upto the top level of the rock with concrete grade not leaner than M10.

For sharp corners especially in skew bridges, through stones shall be used in order to avoid spalling of corners.

In case any stone already set in mortar is disturbed or the joint broken, it shall be taken out without disturbing the adjoining stones and joints, the stone shall be reset in fresh mortar after removing dry mortar and thoroughly cleaning the stones and joints. Sliding of stones on top of another freshly laid stones shall not be permitted.

Shaping and dressing shall be done before the stone is laid in the work. No dressing and hammering, which will loosen the masonry, shall be allowed after it is once placed. All necessary chases for joggles, dowels and clamps shall be formed before hand.

Sufficient transverse bonds shall be provided by the use of bond stones or set of bond stones extending from the front to the back of the wall from outside to the interior and vice versa, overlapping each other by minimum 150 mm. Only rectangular shaped bond stones or headers shall be used. In case natural bond stones of requisite size are not available, precast concrete (M15) bond blocks of size as given in **Table 700.1** shall be used. Cast in situ headers shall not be permitted.

**Table 700.1 Size of Face Stones and Precast Concrete Bond Blocks**

| Size | Height of course (mm) | Minimum acceptable size of face stones (mm) | Preferable size of face stones (mm) | Size of longer stones 1/3rd of total face stones (mm) | Size of precast concrete bond blocks (mm) |
|---|---|---|---|---|---|
| A | 160 | 150x150x200 | 150x180x225 | 150x180x300 | 150x180x450 |
| B | 180 | 170x170x210 | 170x210x255 | 170x210x340 | 170x210x500 |
| C | 220 | 190x190x225 | 190x225x280 | 190x225x380 | 190x225x600 |

At junctions of walls, the stones at each alternate course shall be carried into each of the respective walls so as to unite the work thoroughly.

Building up thin faces tied with occasional through stones and filling up the middle with small stuff or even dry packing shall not be permitted.

All quoin stones and the angles of the opening shall be made from selected stones, carefully squared and bedded and arranged to bond alternately long and short in both directions.

All vertical joints shall be truly vertical and staggered as far as possible. Distance between the nearer vertical joints of upper layer and lower layer shall not be less than half the height of the course.

All connected masonry in a structure shall be carried up nearly at one uniform level throughout but when breaks are unavoidable, the masonry shall be raked in sufficiently long steps to facilitate jointing of old and new work. The stepping of raking shall not be more than 45 degrees with the horizontal.

The face stones shall be hammer dressed on all beds and joints so as to give them approximately regular shape. The face stone shall tail into the work for not less than its height and at least one third of stones shall tail in the work for a length not less than twice of its height. The size of face stones for different preferred height of courses shall be as given in **Table 700.1**.

## 704.3 Coursed Rubble Masonry (First Sort)

### 704.3.1 *Dressing*

Face stones shall be hammer dressed on all beds and joints so as give them approximately rectangular shape. These shall be square on all joints and beds. The beds joints shall be chisel drafted for at least 30 mm back from the face and for at least 30 mm for the side joints. No portion of the dressed surface shall show a depth of gap more than 6 mm from straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints. The requirements regarding bushing shall be same as for random rubble masonry.

### 704.3.2 *Hearting stones*

The hearting or interior filling of the wall shall consist of flat bedded stone carefully laid on their proper beds in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10 percent of the quantity of masonry. While using chips, it shall be ensured that no hollow spaces are left anywhere in the masonry. This shall be ensured by filling the gaps with mortar and inserting chips in it.

### 704.3.3 *Bond stones*

The requirements regarding through or bond stones shall be same as random masonry but these shall be provided at 1.5 m to 1.8 m apart clear in every course.

### 704.3.4 *Quoin stones*

The quoins shall be of the same height of the course in which these occur and shall be formed of header stones not less than 450 mm in length. They shall be laid lengthwise alternately along each face, square in their beds which shall be fairly dressed to a depth of at least 100 mm.

### 704.3.5 *Face stones*

Face stones shall tail into the work for not less than their heights and at least one-third of the stones shall tail into the work for a length not less than twice their height. These shall be laid headers and stretchers alternately.

### 704.3.6 *Laying*

The stones shall be laid on horizontal courses. All vertical joints shall be truly vertical and staggered as far as possible. Distance between the nearer vertical joints of upper layer and lower shall not be less than half the height of the course. The quoin stones rough chisel dressed to a depth of minimum 30 mm, shall be laid stretchers and headers alternately and shall be laid square on their beds, which shall be rough chisel dressed to a depth of at least 30 mm.

### 704.3.7 *Joints*

The face joints shall not be more than 10 mm thick but shall be sufficiently thick to prevent stone to stone contact and shall be completely filled with mortar.

## 704.4 Coursed Rubble Masonry (Second Sort)

### 704.4.1 *General*

All the requirements are the same as for coursed rubble masonry (first sort) except that no portion of dressed surface joints shall show a depth of gap more than 10 mm from a straight edge placed on it and use of chips in hearting stone shall not exceed 15 percent of the quantity of the stone masonry.

Adoption of coursed masonry (second sort) shall be restricted to culverts and wing/return walls of small bridges.

### 704.4.2 *Joints*

The face joints shall be uniform throughout and not be more than 20 mm thick but shall be sufficiently thick to prevent stone to stone contact and shall be completely filled with mortar.

## 704.5 Random Rubble Masonry

Random rubble masonry shall be adopted only in case of return/wing/toe walls of heights less than 5 m.

### 704.5.1 *Dressing*

Stone shall be hammer dressed on the face, the sides and beds to enable it to come in proximity with the neighbouring stone. The bushing on the exposed face shall not be more than 40 mm.

### 704.5.2 *Insertion of chips*

Minimum quantity of chips and spall stones shall be used wherever necessary to avoid thick mortar beds or joints and it shall also be ensured that no hollow spaces are left anywhere in the masonry. The chips shall not be used below hearting stones to bring these upto the level of face stones. Use of chips shall be restricted to filling of interstices between the adjacent stones in hearting and they shall not exceed 20 percent of the quantity of stones masonry.

### 704.5.3 *Hearting stones*

The hearting or interior filling of wall face shall consist of rubble stones not less than 150 mm in any direction, carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar. The hearting shall be laid nearly level with facing and backing.

### 704.5.4 *Bond stones*

Bond stones are selected long stones, used to hold a wall together transversely. Through bond stones shall be provided in masonry upto 600 mm thickness and in case of masonry above 600 mm thickness, a set of two or more bond stones overlapping each other at least by 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous limestone and sandstones, etc.), the bond stone shall extend only about two-third into the wall, as through stones in such cases may give rise to penetration of dampness and therefore, for all thickness of such masonry, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. Minimum one bond stone or a set of bond stones shall be provided for every 0.50 sqm of the masonry surface.

### 704.5.5 *Quoin stones*

Quoin stones, i.e., the stones specially selected and neatly dressed for forming an internal angle in masonry work, shall not be less then 0.03 cum in volume.

### 704.5.6 *Plum stones/Pin headers*

These stones are selected oblong stones embedded vertically in the interior of masonry to form a bond between successive courses. The plum stones embedded in the lower course shall extend to the minimum full height of the upper course and shall be provided at about 1000 mm intervals.

### 704.5.7 *Laying*

The masonry shall be laid with or without course as specified. The quoins shall be laid header and stretcher alternately. Every stone shall be fitted to the adjacent stone so as to form neat and close joint. Face stone shall extend and bond well in the back. These shall be arranged to break joints, as much as possible, and to avoid long vertical lines of joints.

### 704.5.8 *Joints*

The face joints shall not be more than 20 mm thick, but shall be sufficiently thick to prevent stone-to-stone contact and shall be completely filled with mortar.

## 704.6 Dry Rubble Masonry

Dry rubble masonry shall be adopted only in case of breast/retaining walls/toe walls and other incidental works of heights upto 3 m which are not subjected to flood/stagnated water and with specific permission of the Engineer. This work shall conform to Clause 704.5 of Random Masonry except that:

i) the masonry shall be dry without mortar;

ii) the spaces between large stones shall be filled with spalls as tightly as possible; and

iii) the foundations shall be excavated at right angle to the batter face and not horizontally. The beds of the stones shall be laid at right angle to the face batter.

## 704.7 Concrete Block Masonry

### 704.7.1 *General*

Only solid concrete blocks of normal weight conforming to IS:2185 Part-I, shall be used for bridge works. The thickness and width of concrete block shall not be less than 200 mm. The density of concrete block shall not be less than 2.2 tonne/cum.

### 704.7.2 *Laying*

The bed, which is to receive the block, shall be cleaned wetted and covered with a layer of fresh mortar. The masonry works shall be laid to lines, levels, curves and shapes as shown in the drawings. In battered sections, the beds of blocks and the plane of courses shall be horizontal. Face blocks for such sections shall be manufactured specially for the purpose.

The block shall be soaked in water for at least 15 minutes before laying to prevent absorption of water from mortar.

The concrete block masonry shall be constructed generally like fine tooled Ashlar masonry. Each block must be fitted into its place dry in order that discrepancy of figure may be discovered and corrected before it is finally laid in mortar and settled in bed. The block shall be laid full in thin mortar, the bed and side joints being not more than 15 mm in thickness. Each block shall be struck with a wooden mallet when laid in place in mortar to bring it to solid bearing as to bed and joints. All visible edges shall be quite free from chippings.

The courses shall be horizontal and side joints vertical throughout unless otherwise indicated in the drawings. Joints shall be struck.

For bond, face blocks shall be laid header and stretcher alternately unless otherwise directed by the Engineer, the header being arranged to come as nearly as possible in the middle of stretchers below. The blocks in the courses above and below shall break joints for about half the height of the course and bond shall be carefully maintained throughout section.

While carrying out masonry work, templates prepared to the correct shape and approved by the Engineer shall be used to ensure correct batter as well as correct shape of masonry specially cut and ease water end. The finished work shall be checked at every stage by the Engineer to ensure that it has the correct shape and batter as required by design.

In case of skew bridges and for cut and ease water, the acute angle at the corners shall not be less than 45 degrees. In case, the smaller angle cannot be avoided, then a flat face of 100 mm be provided.

### 704.7.3 *Joints*

The joints shall not be more than 15 mm thick and shall be completely filled with mortar.

## 704.8 Pointing

Pointing shall be provided only if specified in the drawings. Pointing if specified, shall be carried out using mortar not leaner than 1:3 by volume of cement and sand or in proportion shown on the drawings. The mortar shall be filled and pressed into the raked out joints before giving the required finish.

The pointing shall conform to Section 600 of these Specifications. Raised pointing which projects beyond the face of stone masonry shall not be used.

## 704.9 Curing

Curing shall conform to Section 600 of these Specifications.

## 705 SCAFFOLDING & CENTERING

Scaffolding and centering shall conform to Section 600 of these Specifications.

## 706 STONE MASONRY ARCH

Stone masonry arch bridges having span more than 6 m shall not be constructed in seismic zones IV and V. A full scale shape of arch shall be laid on a levelled platform near the construction site and size of each stone and mortar thickness marked. The stones shall then be cut accordingly. In outer rings of arch, the alternate stone shall have long length and short length. Remaining stones in the inner part of the arch shall be placed to have as far as possible uniform length. The courses shall be as shown in the drawings. The drawing shall indicate the order in which voussoirs shall be placed. Voussoirs shall be full size throughout and shall have bond not less than their thickness. Beds shall be properly adjusted to bring them to radial planes. Radial joints shall be in planes parallel to the transverse axis of the arch. The intrados face shall be dressed sufficiently to permit the stones to rest properly on the centering. The stones of the spandrel wall at their junctions with the extrados of the arch shall be cut to fit in the curvature of the arch.

Laying of arches shall commence from both ends towards the crown and the work shall be carried out systematically, stones being placed in full mortar beds and joints grouted if required. Pinning by use of spalls or such material of any description shall not be permitted. Each stone shall be first fitted dry, in order that inaccuracies are found out and corrected by stone cutter before it is finally laid into mortar and fixed in its bed.

The masonry work shall be done in not leaner than 1:4 cement mortar.

## 707 JOINTING OLD AND NEW MASONRY WORK

For jointing old and new masonry, shall be as per Section 600 of these Specifications.

## 708 FINISHING OF SURFACES

All stone masonry work shall be finished in a workmanlike manner with the thickness of joints and manner of striking or tooling as described in these Specifications or as shown on the drawings.

The surfaces shall be finished by ‘jointing’ or ‘pointing’ as given on the drawings.

For a surface which is to be subsequently pointed, the joints shall be squarely raked out to a depth of 15 mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted.

The mortar for finishing shall be prepared as per Section 600 of these Specifications.

## 709 WEEP HOLES

Weep holes shall be provided as per Section 1200 of these Specifications.

## 710 ARCHITECTURAL COPING FOR WING/RETURN/PARAPET WALLS

This work shall consist of providing an architectural coping over the top of wing/return/parapet walls as per the drawings.

The material used shall be cement mortar 1:3 or as shown on the drawings prepared in accordance with Section 600 of these Specifications.

The cement mortar shall be laid evenly to an average thickness of 15 mm to the full width of the top of the wall and in a band of 150 mm depth along the top outer face of the walls.

## 711 TOLERANCES, TESTS AND STANDARDS OF ACCEPTANCE

All work shall be done true to the lines and levels as shown on the drawings or as directed by the Engineer subject to the tolerances as specified in these Specifications for different components of structure.

All materials shall be tested in accordance with stipulations given in Section 2000 of these Specifications.

Mortar cubes shall be tested in accordance with IS:2250 for compressive strength, consistency and its water retentivity. The frequency of testing shall be one cube for every 2 cum of mortar prepared subject to a minimum of 3 cubes for a day's work. Section 1800 shall also apply for tests on stone and concrete block masonry.

## 712 MEASUREMENTS FOR PAYMENT

All stone and concrete block masonry work shall be measured in cubic metres. Any extra work done by the Contractor over the specified dimensions shall be ignored and not measured.

In arches, the length of arch shall be measured as the mean length between the extrados and intrados.

The work of pointing shall be measured in square metres of the surface treated.

Architectural coping shall be measured in linear metres.

## 713 RATE

The contract unit rate for stone and concrete block masonry work shall include the cost of all labour, materials, tools and plant, scaffolding including centering if required, sampling, testing, supervision and other expenses incidental to the satisfactory completion of the work as described in these Specifications.

The contract unit rate for work shall also include full compensation for using dressed stones on faces of walls with batter.

The contract unit rate for pointing shall include cost of all labour, materials, tools and plants for erection and removal of scaffolding including centering if required, and all incidental expenses to complete the pointing, i.e., raking out joints, cleaning, wetting, filling with mortar, trowelling, pointing and watering, sampling and testing and supervision as described in these Specifications.

The contract unit rate for architectural coping shall include cost of all labour, materials, tools and plant, all incidental expenses, sampling and testing and supervision as described in these Specifications.

## 800

# CONCRETE FOR STRUCTURES

## 801 SCOPE

These Specifications cover the requirements of cement concrete for use in various components of structures. The work shall consist of supplying and placing of concrete using all materials in accordance with these Specifications and in conformity with the lines, grades and dimensions, as shown on the drawings or as directed by the Engineer.

## 802 MATERIALS

All materials shall conform to the requirements of Section 2000 of these Specifications.

## 803 GRADES OF CONCRETE

The concrete shall be in grades designated as per **Table 800.1**, where the characteristic strength is defined as the strength of concrete below which not more than 5 percent of the results are expected to fall.

**Table 800.1 Grades of Concrete**

| Type of Concrete/Grade Designation | | Characteristic Strength in MPa |
|---|---|---|
| **Nominal Mix Concrete** | **Design Mix Concrete** | |
| M15 | M15 | 15 |
| M20 | M20 | 20 |
| | M25 | 25 |
| | M30 | 30 |
| | M40 | 40 |
| | M45 | 45 |

The lowest grades of concrete and corresponding cement contents and water-cement ratios shall be maintained as given in **Table 800.2**.

The cement content shall be as low as possible but not less than the quantities specified above. In no case shall it exceed 450 kg/cum of concrete.

Concrete used in any structure shall be, apart from its grade designation, specified either as "Design Mix" or "Nominal Mix".

Design mix concrete is that concrete for which the design of mix, i.e., the determination of the proportions of cement, aggregates and water is arrived at to have a target mean strength of concrete, is done. "Nominal Mix" concrete is that concrete for which the proportions of materials are specified.

For all items of concrete, "Design Mix" shall be preferred to "Nominal Mix" because of better quality and it requires less quantity of cement than the quantity required for nominal mix for a specified grade.

Nominal mix for grades higher than M20 is not recommended. However, as per policy decision taken for culverts and small bridges involving small quantity of concrete work, nominal mix of grades M20 and M25 may be used with adequate supervision and quality control measures. Nevertheless, it will be preferable to use design mix in place of nominal mix for concrete of M20 and higher grades.

The mix shall be designed by weigh batching. For ease of production at site, volumetric batching may also be permitted after making adjustments for bulking of aggregates by using appropriate size of boxes of half or full bag capacity and quantity of water adjusted for the surface water carried by the coarse and fine aggregates. The size of the boxes shall be large enough to eliminate error in proportioning of mix and which can be handled manually. The cement shall, however, be mixed by weight or number of full bags (weighing 50 kg).

**Table 800.2 Requirement of Concrete for Different Exposure Condition using 20 mm aggregate**

| Exposure Condition | Maximum Water Cement Ratio | Minimum Cement Content, kg/m$^3$ | Minimum Grade of Concrete |
|---|---|---|---|
| Moderate | 0.45 | 340 | M25 |
| Severe | 0.45 | 360 | M30 |
| Very Severe | 0.40 | 380 | M40 |

***Note:***

i) All three provisions given in the above Table 800.2 for a particular exposure condition, shall be satisfied.

ii) The term cement for maximum w/c ratio and minimum cement content shown in Table includes all cementitious materials. The maximum limit of fly ash and ground granulated blast furnace slag in the blended cement shall be as specified in IS:1489 (Part 1) and IS:455 respectively.

iii) For plain cement concrete, with or without surface reinforcement, the minimum grade of concrete can be lowered by 5 MPa and maximum water/cement ratio exceeded by 0.05.

Cement content indicated in the above table shall be increased by 40 kg/m$^3$ for use of 12.50 mm nominal size aggregates and decreased by 30 kg/m$^3$ for use of 40 mm nominal size aggregates.

## 804 PROPORTIONING OF CONCRETE

### 804.1 General

Prior to the start of construction, the Contractor shall design the mix in case of "Design Mix Concrete" or propose nominal mix in case of "Nominal Mix Concrete", and submit to the Engineer for approval, the proportions of the materials, including water reducing admixtures proposed to be used.

No material other than the essential ingredients, i.e., cement, aggregates and water, shall be used in the manufacture of concrete. The Engineer may however, permit the use of approved water reducing admixtures (with chloride contents not more than 0.2 percent when tested in accordance with IS:6925), conforming to IS:9103 for imparting special characteristics to concrete, on satisfactory evidence that its use does not in any way adversely affect the properties of concrete particularly its strength, volume changes, durability and has no harmful effect on reinforcement.

### 804.2 Requirements of Consistency

The mix proportion shall be selected to ensure the workability of the fresh concrete to surround and properly grip all reinforcement, required strength, durability and finish when hardened.

Maximum slump for different types of works when checked as per IS:516 shall be as given in Table 800.3 or as specified in the drawings.

**Table 800.3 Requirements of Consistency**

| | Type | Slump (mm) (at the Time of Placing of Concrete) |
|---|---|---|
| 1 | a) Structure with exposed inclined surface requiring low slump concrete to allow proper compaction | 25 |
| | b) Plain cement concrete | 25 |
| 2 | RCC structure with widely spaced reinforcements; e.g. solid columns, piers, abutments, footings, well steining | 40 – 50 |
| 3 | RCC structure with fair degree of congestion of reinforcement; e.g. pier and abutment caps, box culverts, well curb, well cap, walls with thickness greater than 300 mm | 50 – 75 |
| 4 | RCC and PSC structure with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300 mm | 75 – 125 |
| 5 | Underwater concreting through tremie e.g. bottom plug, cast in-situ piling | 150 – 200 |

Notwithstanding the optimum consistency indicated against Sl. No. 1 to 3, the situation should be property assessed to arrive at the desired workability with the adjustment of admixture in each case, where the concrete is to be transported through transit mixer and placed using concrete pump. Under these circumstances, the optimum consistency during placement for the items of work of Sl. No. 1 to 3, can be considered ranging from 75 mm to 150 mm. This is, however, subject to satisfying the other essential criteria of strength, durability etc. and approval of the Engineer.

### 804.3 Requirements of Design Mix Concrete

### 804.3.1 *Target mean strength*

The target mean strength of specimen shall exceed the specified characteristic compressive strength by at least the current margin.

i) The current margin for a concrete mix shall be determined by the Contractor and shall be taken as 1.64 times the standard deviation of sample test results taken from at least 40 separate batches of concrete of nominally similar proportions produced at site by the same plant under similar supervision, over a period exceeding 5 days, but not exceeding 6 months.

ii) Where there is insufficient data to satisfy the above, the current margin for the initial design mix shall be taken as given in **Table 800.4** :

**Table 800.4 Current Margin for Initial Design Mix**

| Concrete Grade | Current Margin (MPa) | Target Mean Strength (MPa) |
|---|---|---|
| M15 | 10 | 25 |
| M20 | 10 | 30 |
| M25 | 11 | 36 |
| M30 | 12 | 42 |
| M35 | 12 | 47 |
| M40 | 12 | 52 |
| M45 | 13 | 58 |

The initial current margin given in **Table 800.4** shall be used till sufficient data is available to determine the current margin as per Sub-clause 804.3.1 i).

### 804.3.2 *Trial mixes*

i) The Contractor shall give notice to the Engineer to enable him to be present at the time of carrying out trial mixes and preliminary testing of the cubes. Prior to commencement of trial mix design, all materials forming constituents of proposed design mix should have been tested and approval obtained in writing from the Engineer. Based on test results of material, draft mix design calculation for all grades of concrete to be used in the works, shall be prepared after taking into account the provisions in the Contract Technical Specifications, guidelines of IS:10262, IS:SP-23 and IRC:112 and submitted to the Engineer for approval. Prior to commencement of concreting, trial mix design shall be performed for all grades of concrete and trial mix which has been found successful, shall be submitted by the Contractor and approval obtained. During concreting with the approved trial mix design, if source of any constituents is changed, the mix design shall be revised and tested for satisfying the strength requirements.

ii) The initial trial mixes shall be carried out in a laboratory approved by the Engineer. However, the Engineer may permit the initial trial mixes to be prepared at the site laboratory of the Contractor, if a full fledged concrete laboratory has been established well before the start of construction, to his entire satisfaction. Sampling and testing procedures shall be in accordance with these Specifications.

iii) When the site laboratory is utilized for preparing initial mix design, the concrete production plant and means of transport employed to make the trial mixes shall be similar to those proposed to be used in the works.

iv) For each trial mix, a set of six cubes shall be made from each of three consecutive batches for purposes of testing. Three cubes from each set of six shall be tested at an age of 28 days and three at an earlier age approved by the Engineer. The cubes shall be made, cured, stored, transported and tested in accordance with these Specifications. The mean strength of the nine cubes at 28 days shall exceed the specified characteristic strength by the current margin minus 3.5 MPa.

### 804.3.3 *Control of strength of design mixes*

a) Adjustment to Mix Proportions

Adjustment to mix proportions arrived at in the trial mixes, shall be made subject to the Engineer's approval, in order to minimize the variability of strength and to maintain the target mean strength. Such adjustments shall not be taken to imply any change in the current margin.

b) Change of Current Margin

When required by the Engineer, the Contractor shall recalculate the current margin in accordance with Clause 804.3.1. The recalculated value shall be adopted as directed by the Engineer, and it shall become the current margin for concrete produced thereafter.

c) Additional Trial Mixes

In case any changes are observed in the properties of fresh concrete and/or strength of hardened concrete on the basis of early age tests, additional mixes and tests shall be carried out during production, so as to control and bring the quality of concrete within acceptable limits. In case of any change in the source or properties of materials, the design of mix shall be established afresh.

## 804.4 Requirements of Nominal Mix Concrete

### 804.4.1 *General*

Nominal mix concrete shall generally be specified by grades of concrete.

Proportion of ingredients of concrete shall be by mass. Water shall either be measured by volume in calibrated tanks or weighed.

Where the weight of cement is determined by accepting the maker's weight per bag, a reasonable number of bags shall be weighed separately to check the net weight. The cement shall be measured by number of full bags to avoid error in proportioning.

Volume batching shall be permitted only after the accurate determination of bulk densities of coarse and fine aggregates proposed to be used in the works. Allowance for bulking shall be made in accordance with IS:2386 (Part 3). The mass volume relationship shall be checked frequently as necessary, the frequency being determined by the Engineer to ensure that the required grading is maintained.

It is important to keep the specified water-cement ratio constant and at its correct value. Moisture content in both fine and coarse aggregates shall therefore, be determined as per IS:2386 (Part 3) as frequently as possible. The frequency shall be as determined by the Engineer according to the weather conditions. The amount of mixing water shall then be adjusted to compensate for variations in the moisture content. Suitable adjustment shall also be made in the weights of aggregates to allow for the variation in weight of aggregates due to variation in their moisture content.

In the absence of exact data, the amount of surface water may be estimated from the values given in **Table 800.5** and volumetric proportions of fine, coarse aggregates and quantity of water to be mixed shall be accordingly modified.

**Table 800.5 Surface Water Carried by Aggregate**

| | Aggregate | Approximate Quantity of Surface Water | |
|---|---|---|---|
| | | Percent by mass | Litres/cum |
| i) | Very wet sand | 7.5 | 120 |
| ii) | Moderately wet sand | 5.0 | 80 |
| iii) | Moist sand | 2.5 | 40 |
| iv) | Moist gravel or crushed rock* | 1.25-2.5 | 20-40 |

*Coarser the aggregate, less the water it will carry.

No substitutions in materials or change in the established proportions, except for adjustment due to moisture content in the ingredients and bulking shall be permitted without additional tests to prove that the quality and strength of concrete are satisfactory and approval by the Engineer.

### 804.4.2 *Proportions of materials*

Proportions of materials shall be in accordance with **Table 800.6** unless otherwise specified.

Table 800.6 Requirements for Nominal Mix Concrete

| Concrete Grade | Total Quantity of Dry Aggregate by mass per 50 kg of cement to be taken as the sum of individual masses of fine and coarse aggregates (kg) | Proportion of Fine to Coarse Aggregate (by mass) | Maximum Quantity of Water for 50 kg of Cement (litres) | |
|---|---|---|---|---|
| | | | PCC | RCC |
| M15 | 350 | Generally 1:2, subject to upper limit 1:1.5 and lower limit of 1:2.5 | 25 | |
| M20 | 250 | | 25 | 22 |

## 804.5 Additional Requirements

Concrete shall meet any other requirements as specified on the drawing or as directed by the Engineer. The overall limits of deleterious substances in concrete shall be as follows:

a) Total acid soluble chloride content in the concrete mix expressed as chloride ions shall not exceed the following values by mass of cement.

| | |
|---|---|
| Prestressed concrete | 0.10 percent |
| Reinforced concrete (in severe, very severe or extreme exposure condition) | 0.20 percent |
| Reinforced concrete in moderate exposure condition | 0.30 percent |

b) The total water soluble sulphate content of the concrete mix expressed as $SO_3$, shall not exceed 4 percent by mass of cement in the mix.

For concrete made with Portland pozzolona cement, Portland blast furnace slag cement or mineral admixtures, the setting time and rate of gain of strength are different from those for concrete made with OPC alone. Such modified properties shall be taken into account while deciding the de-shuttering time, curing period, early age loading and time of prestressing. Additional cube samples may be required to be taken for verifying the concrete properties.

## 804.6 Suitability of Proposed Mix Proportions

The Contractor shall submit the following information for the Engineer's approval :

a) Nature and source of each material

b) Quantities of each material per cubic metre of fully compacted concrete

c) Either of the following :

   i) Appropriate existing data as evidence of satisfactory previous performance for the target mean strength, current margin, consistency and water/cement ratio and any other additional requirement (s) as specified.

ii. full details of tests on trial mixes.

d) Statement giving the proposed mix proportions for nominal mix concrete

Any change in the source of material or in the mix proportions shall be subject to the Engineer's prior approval.

### 804.7 Checking of Mix Proportions and Water/Cement Ratio

In proportioning concrete, the quantity of both cement and aggregate shall be determined by weight. Where the weight of cement per bag as given by the manufacturer is accepted, a reasonable number of bags shall be weighed separately to check the net weight. Where cement is weighed from bulk stock at site and not by bag, it shall be weighed separately from the aggregates. Water shall either be measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be periodically checked.

The specified water/cement ratio shall always be kept constant and at its correct value. To this end, moisture content in both fine and coarse aggregates shall be determined as frequently as possible, the frequency for a given job being determined by the Engineer according to the weather conditions. The amount of water to be added shall then be adjusted to compensate for variations in the moisture content. For the determination of moisture content in the aggregates IS:2386 (Part III) shall be referred. Suitable adjustments shall also be made in the weight of aggregates to allow for their variation in weight due to variation in their moisture content.

### 804.8 Size of Coarse Aggregates

The size (maximum nominal) of coarse aggregates for concrete to be used in various components shall be as given in **Table 800.7**.

**Table 800.7 Maximum Nominal Size of Coarse Aggregates**

| Components | Maximum Nominal Size of Coarse Aggregate (mm) |
|---|---|
| i) RCC well curb | 20 |
| ii) RCC/PCC well steining | 40 |
| iii) Well cap or Pile Cap, Solid type piers and abutments | 40 |
| iv) RCC work in girder, slabs, wearing coat, kerb, approach slab, hollow piers and abutments, peir/abutment caps, piles | 20 |
| v) PSC Work | 20 |
| vi) Any other item | As specified by the Engineer |

Maximum nominal size of aggregates shall also be restricted to the smaller of the following values :

a) 10 mm less than the minimum lateral clear distance between individual reinforcements

b) 10 mm less than the minimum clear cover to the reinforcement

c) One quarter of minimum thickness of member

The proportions of the various individual sizes of aggregates shall be so adjusted that the grading produces the densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

## 805 EQUIPMENT

Unless specified otherwise in the Notice Inviting Tenders/contract documents/drawings, the equipment for production and compaction of concrete shall be as follows:

a) For Production of Concrete:

Mechanical mixer (minimum one bag capacity) conforming to IS:1791 and IS:12119 fitted with water measuring device for culverts/small bridges with length less than 60 m and individual span less than 15 m. Mechanical mixer fitted with small load cell shall be preferred. However, for controlled concrete mix of M25 for superstructure, mechanical mixer of minimum 200 litres capacity having integral weigh batching facility (hydraulic/pneumatic type), automatic water measuring and dispensing device shall be used.

All measuring devices of equipment shall be maintained in a clean and serviceable condition. Its accuracy shall be checked over the range in use, when set up at each site and thereafter periodically as directed by the Engineer.

The accuracy of the measuring devices shall fall within the following limits:

| | | |
|---|---|---|
| Measurement of Cement | ±3 percent of quantity of cement | in each batch. |
| Measurement of Water | ±3 percent of quantity of water | in each batch. |
| Measurement of Aggregate | ±3 percent of quantity of aggregate | in each batch. |
| Measurement of Admixture | ±5 percent of quantity of admixture | in each batch. |

b) For Compaction of Concrete:

| | | |
|---|---|---|
| i) | Internal vibrators conforming to IS:2505 | 25 to 70 mm size |
| ii) | Form vibrators conforming to IS:4656 | minimum 500 watts |
| iii) | Screed vibrators conforming to IS:2506 | Full width of carriageway (upto two lanes) |

## 806 MIXING OF CONCRETE

For all works, concrete shall be mixed in a mechanical mixer complying with IS:1791 and IS:12119 fitted with water measuring device. The mixer and other accessories shall be kept in first class working condition and so maintained throughout the construction. Mixing shall be continued till materials are uniformly distributed and a uniform colour and consistency of the entire mass is obtained. Further, each individual particle of the coarse aggregate shall show complete coating of mortar containing its proportionate amount of cement. If there is segregation after unloading from the mixer, the concrete shall be remixed. In no case shall the mixing be done for less than 2 minutes after all ingredients have been put into the mixer.

Mixer which has been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch. Unless otherwise agreed to by the Engineer, the first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregates. Mixing plant shall be thoroughly cleaned before changing from one type of cement or a grade of concrete to another.

Hand mixed concrete shall not be used in structural concrete. However, when hand mixing is permitted by the Engineer for small isolated culverts (upto 2 m span) in remote areas or for certain other reasons, 10 percent extra cement shall be used and the cost of extra cement shall be borne by the Contractor. Graduated/measuring cans shall be used for measuring water. The mixing shall be done on a smooth watertight platform large enough to allow efficient turning over of the ingredients of concrete before and after adding water. Mixing platform shall be so arranged that no foreign material shall get mixed with concrete nor does the mixing water flow out. Cement in required number of bags shall be placed in a uniform layer on top of the measured quantity of fine aggregates, which shall also be spread in layer of uniform thickness on the mixing platform. Dry fine aggregate/sand and cement shall then be mixed thoroughly by turning over to get a mixture of uniform colour. Measured quantity of water shall then be added gradually and the mass turned over till a mortar of required consistency is obtained. Measured quantity of coarse aggregates shall then be placed on the mixing platform and wetted, mortar added and the entire mass turned and re-turned until all particles of the coarse aggregates are fully covered with mortar and the mixture obtained is of uniform colour and required consistency. The quantity of total water added shall not exceed the maximum value given in **Table 800.6**.

During hot weather, the aggregates and water shall be cooled before mixing while in cold weather, the aggregates and water shall be heated before mixing so that the temperature of the concrete at the time of placing in position is within permissible limits (5ºC to 40ºC). The methods of cooling or heating of aggregates and water shall be as approved by the Engineer. Cement shall not be heated under any circumstances.

## 807 TRANSPORTING, PLACING AND COMPACTION OF CONCRETE

After mixing, concrete shall be transported to the formwork as quickly as possible. The method and arrangement of transporting and placing concrete shall be approved by the Engineer. Concrete shall be so transported and placed that no contamination, segregation or loss of its constituent materials or ingress of foreign matter or water takes place and the required workability is also maintained.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods as approved by the Engineer to reduce the loss of water by evaporation shall also be adopted.

All formwork and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete.

No concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained.

If concreting is not started within 48 hours of the approval being given, the Contractor shall take fresh approval from the Engineer. Concreting then shall proceed continuously over the area between construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a proper construction joint is formed.

Concrete when deposited shall have a temperature of not less than 5ºC and not more than 40ºC. It shall be compacted before the initial setting of the concrete but not later than 30 minutes of its discharge from the mixer.

Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used and not more than 300 mm in other cases.

The method of placing of concrete shall be such as to preclude segregation. Care shall be taken to avoid displacement of reinforcements or form work.

The concrete shall not be dropped freely into place from a height exceeding 1.5 m.

Concrete shall be thoroughly compacted by vibrations using internal (needle) vibrators of suitable size or form vibrators during placing and worked around the reinforcement, embedded fixture and into corners of the form work to produce a dense homogeneous void free mass having the required surface finish.

Needle vibrators have generally radius of action of about four times its diameter. The internal vibrators used for compacting the fresh concrete shall be inserted vertically to the full depth of layer being placed and ordinarily shall also penetrate the layer below for a few centimetres. The vibrator shall be kept in place until air bubbles stop coming out from the surface, the coarse aggregate particles get fully embedded, surface becomes level and a thin film of paste appears along the head of the vibrator. The internal vibrator shall be withdrawn slowly so that the hole left by it in the concrete gets closed without entrapping any air. The vibrator has to be reinserted in case the hole does not get filled up. The vibrators shall be inserted in orderly manner and the distance between insertions shall be about one and a half times the radius of the area visibly affected by vibration. The vibration shall be applied continuously during the placing of each batch of concrete. Vibrations by direct contact of vibrators with reinforcement during compaction shall be avoided. Vibrators shall not be used to move the concrete. Over vibration shall be avoided to minimize the risk of segregation and forming a weak surface layer. When external vibrators are used, the design of formwork and disposition of vibrator shall be such as to ensure efficient compaction and to avoid surface defects.

Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns.

Mechanical vibrators used shall comply with IS:2505, IS:2506, IS:2514 and IS:4656.

## 808 CONCRETING UNDER WATER

When it is necessary to deposit concrete under water, the concrete shall not be permitted to fall freely through water. The method, equipment, materials and proportions of the mix to be used shall be got approved from the Engineer before any work is started.

Concrete shall not be placed in water having a temperature below 5°C. The temperature of the concrete, when deposited, shall be not less than 16°C and not more than 30°C.

Concrete shall contain 10 percent more cement than that required for the same mix placed in the dry. The cost of additional cement shall be borne by the contractor. The materials shall be so proportioned as to produce a concrete having a slump of not less than 100 mm, and not more than 180 mm. when tested as per IS:516.

Coffer-dams or forms shall be sufficiently tight to ensure still water conditions if practicable, and in any case to reduce the flow of water to less than 3 m per minute through the space into which concrete is to be deposited. Coffer-dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping if required, shall not be done while concrete is being placed, or until 24 hours thereafter.

Concrete shall be deposited continuously until it has been brought to the required height. While depositing, the top surface shall always be kept as nearly level as possible. Drop bucket method or any other method approved by the Engineer may be used for depositing concrete under water.

Drop bottom bucket method: The top of the bucket shall be closed. The bottom doors shall move freely downward and outward when tripped. The bucket shall be filled completely and lowered slowly to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

To minimize the formation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

## 809 WORKING IN EXTREME WEATHER

Where concrete is to be deposited at or near freezing temperatures, precautions shall be taken to ensure that at the time of placing, it has a temperature of not less than 5°C and that the temperature after the concrete has been placed and compacted is maintained above 4°C until it has thoroughly hardened. When necessary, the concrete ingredients shall be heated before mixing but the cement shall not be heated artificially other than heat transmitted to it from other ingredients of the concrete. Generally heating of the mixing water alone may be sufficient for this purpose. The temperature of water shall not however be more than 65°C. The concrete shall be carefully protected after placing.

Salt or other chemicals shall not be used to prevent water from freezing. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to freezing weather shall have entrained air and water cement ratio shall not be more than 0.60.

When depositing concrete in very hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 40°C while placing. This shall be achieved by stacking aggregates under the shade and keeping them moist, using cold water, reducing the time between mixing and placing to the minimum, cooling form work by sprinkling water, starting curing before concrete dries out and restricting concreting, as far as possible, to early mornings and late evenings. When ice is used to cool mixing water, it will be considered a part of the water for the purpose of working out the water-cement ratio in the mix.

## 810 PROTECTION & CURING

Concreting operations shall not be started until adequate arrangements for proper curing of concrete have been made by the Contractor.

Curing is the process for preventing the loss of moisture from the concrete. The prevention of moisture loss from the concrete is particularly important if the water-cement ratio is low.

Curing and protection shall start immediately after the compaction of the concrete to protect it from:

a) Premature drying out due to sun, heat and wind.
b) High internal thermal gradients.
c) Leaching out by rain and flowing water.
d) Rapid cooling during the first few days after placing.
e) Low temperature or frost.
f) Vibrations and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

### 810.1 Water Curing

Water for curing shall conform to Section 2000 of these Specifications. Sea water shall not be used for curing. After one or two hours of concreting, the concrete shall be protected from quick drying by covering with moist gunny bags, canvas, Hessian or similar material as approved by the Engineer. After 24 hours, all exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacks, canvas, Hessian, or similar materials and shall be kept constantly wet for a period of not less than fourteen days from the date of placing of concrete except in the case of concrete with rapid hardening cement, where it can be reduced to five days. Water should be applied on surfaces after the final set. Curing through watering shall not be done on green concrete. On formed surfaces, curing shall start immediately after the forms are stripped. The concrete shall be kept constantly wet with a layer of sacking, canvas, hessian or similar absorbent material.

### 810.2 Curing Compounds

Curing compounds shall only be permitted in special circumstances and with specific approval of the Engineer. Curing compounds shall not be used on any surface which requires further finishing to be applied. All construction joints shall be moist, cured and no curing compound shall be permitted in locations where concrete surfaces are required to be bonded together.

Curing compounds shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of concrete finish. If the surface is dry, the concrete shall be saturated with water and curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

Masonry work over the foundation concrete shall not be started earlier than 48 hours of its laying but the curing of concrete shall be continued for minimum period of 14 days.

## 811 FINISHING

Immediately on removal of forms, the concrete shall be examined by the Engineer before any defects are made good.

All exposed bars or bolts passing through the reinforced cement concrete member and used for shuttering or any other purpose shall be cut inside the reinforced cement concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes be closed by cement mortar. All fins caused by form joints, all cavities produced by the removal of form ties and all other holes and depressions, honeycomb spots, broken edges or corners, and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed and rendered true with mortar of cement and fine aggregate mixed in the proportions used in the grade of concrete that is being finished and of as dry a consistency as is possible to use. Considerable pressure shall be applied in filling and pointing to ensure thorough filling in of all voids. Surfaces which have been pointed shall be kept moist for a period of twenty four hours.

All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

The portion of concrete, which is porous or honey combed or its placing has been interrupted without providing proper construction joint or construction tolerances have not been met or reinforcement has been displaced to an extent detrimental to structural safety shall be rejected, removed and replaced as per the directions of the Engineer.

Surface defects of minor nature shall be rectified as directed by the Engineer.

## 812 CONSTRUCTION JOINTS

Construction joints shall be avoided as far as possible and in no case the locations of such joints shall be changed or increased from those shown on the drawings. The joints, if provided shall be in a direction perpendicular to the axis of the member.

Concreting shall be carried out continuously upto the construction joints, the location and details of which shall be as shown on the drawings or as determined by the Engineer.

For a vertical construction joints, a stooping board shall be fixed previously at the pre-determined position and shall be properly stayed for sufficient lateral rigidity to prevent its displacement or bulging when concrete is compacted against it. Concreting shall be continued right up to the board. The board shall not be removed before the expiry of 24 hours after the concreting.

Before resuming work at any construction joint when concrete has not yet fully hardened, all laitance shall be removed by scrubbing the wet surface with stiff wire or bristle brushes, care being taken to avoid dislodgement of any particle of coarse aggregate. The surface shall then be thoroughly wetted, all free water removed, and then coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 150 mm in thickness, and shall be well rammed against old work, particular attention being paid to corners and close spots.

When work has to be resumed on a surface which has hardened, it shall be thoroughly hacked without dislodgement of coarse aggregates, cleaned to remove loose material, debris and accumulated dust/rubbish etc, wetted and covered with a layer of neat cement grout. The neat cement grout shall be followed by a 10 mm thick layer of cement mortar mixed in the same proportion as that of cement and sand in concrete and concreting resumed immediately thereafter. The first batch of concrete shall be rammed against the old work to avoid formation of any pockets, particular attention being paid to corners and close spots.

## 813 USE OF PLUMS IN ORDINARY CONCRETE

Stone plums shall not be used unless specified on the drawings.

Plums shall not be used in reinforced concrete or concrete laid under water.

The quantity of plums shall not exceed 15 percent by volume of the concrete.

If round plums are stacked, volume of plums shall be assumed as 60 percent of total volume and 40 percent as voids. This criteria shall be used to measure volume of plums.

The size of plums shall be from 160 to 300 mm. The maximum dimension of the stones or plums shall not exceed 1/3rd the least dimension of the member.

All plums shall be hard, durable, clean and free from soft materials or loose pieces or deleterious substance in them and shall not have sharp corners.

First layer of concrete of the specified mix shall be laid to a thickness of the maximum size of plums proposed to be used. The plums shall then be evenly distributed laid while the top portion of this concrete is still green but sufficiently stiff to prevent complete submergence of the plums under their own weight. These plums shall be about half embedded in the concrete and the remaining part exposed so as to form a key with the next layer of concrete.

While placing the plums, care shall be taken to see that the clear distance between any two plums is not less than either the width or thickness of either of the plums. The distance from plums to the outer surface shall not be less than width of the plum subject to minimum of 150 mm.

If plums of stratified stone are used, they shall be laid on their natural bed. Stones with concave faces shall be laid with the concave upwards.

The thickness of the next and successive layer of concrete shall be at least twice that of the largest plums.

## 814 TOLERANCES

Tolerances for dimensions/shape of various components shall be as specified in these Specifications or shown on the drawings or as directed by the Engineer.

## 815 TESTS AND STANDARDS OF ACCEPTANCE

### 815.1 General

Concrete work shall conform to the surface finish and tolerance for different components of the structure as specified in these Specifications or as shown on drawings or as directed by the Engineer.

Random sampling and lot by lot acceptance inspection shall be made for the 28 days cube strength of concrete.

Concrete under acceptance shall be notionally divided into lots for the purpose of sampling, before the start of work. The delimitation of lots shall be determined by the following:

i) No individual lot shall be more than 30 cum in volume;

ii) At least one cube forming an item of the sample representing the lot shall be taken from concrete of the same grade and mix proportions cast on any day; even if quantity is less than 1 cum.

iii) Different grades of mixing of concrete shall be divided into separate lots;

iv) Concrete of one lot shall be used in the same identifiable member of the cross drainage work.

### 815.2. Sampling and Testing

i) Concrete for making three test cubes shall be taken from a batch of concrete at point of discharge from the mixer in accordance with the procedures laid down in IS:1199.

ii) A random sampling procedure to ensure that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cube shall be adopted. The sampling shall be spread over the entire period of concreting covering all mixing units.

iii) 150 mm cubes shall be made, cured and tested at 28 days age for compressive strength conforming to IS:516. The 28 days test strength result for each cube shall form an item of the sample representing a lot.

### 815.3 Test Specimens and Sample Strength

Three test specimens shall be made from each sample for testing at 28 days. Additional set of specimens shall be made to determine the strength of concrete at 7 days or for removal of formwork or any other purpose if directed by the Engineer.

The test strength of the sample shall be the average of the strength of three cubes. The individual variation in test strength shall not exceed ± 15 percent of the average test strength.

### 815.4 Frequency

The minimum frequency of sampling of concrete of each grade shall be as given in **Table 800.8**.

**Table 800.8**

| Quantity of concrete in work (in cum) | No. of Samples |
|---|---|
| 1-5 | 1 |
| 6-15 | 2 |
| 16-30 | 3 |
| 31-50 | 4 |

At least one sample shall be taken for each shift of work.

### 815.5 Acceptance Criteria

All materials shall comply with the requirements of quality and fitness for the works as specified in Clause 802.

Acceptance decision shall be taken lot by lot and samples of different lots shall not be clubbed for the purpose of acceptance. Test strength result of each cube shall form an item of the sample representing a lot.

The concrete shall be deemed to comply with strength requirements when both the following conditions are satisfied:

i) The mean strength of any group of four consecutive samples shall exceed the specified characteristic compressive strength by 3 MPa.

ii) The strength of any sample shall not be less than the specified compressive strength minus 3 MPa.

The quantity of concrete represented by the test results shall include the batches from which first and last samples were taken, together with all intervening batches.

Total water soluble sulphate ($SO_3$) content of concrete shall not exceed 4 percent by mass of cement used in the mix.

Total chloride content in concrete expressed as chloride-ion shall not exceed 0.30 percent by mass of cement used under moderate conditions of exposure and 0.20 percent under severe conditions of exposure.

In addition, provisions of Section 1800 shall apply.

If the concrete is not able to meet any of the standards of acceptance as specified, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. The investigations shall be carried out at Contractor's cost. If the results of the investigations adequately prove that the structure meets the required criteria for safety during service, the Engineer may accept the concrete provided the actual average strength of sample is not less than 85 percent of the specified strength of the concrete. In case any additional work is required to be done for such acceptance and to bring the structure to the required level for safety during service, the same shall be carried out by the Contractor at his cost. In case the concrete is not found to be acceptable after investigations, the Contractor shall remove the rejected concrete and replace the same with new concrete.

## 816 MEASUREMENTS FOR PAYMENT

The cement concrete shall be measured in cubic metres. In reinforced concrete, the volume occupied by reinforcement shall not be deducted. The slab shall be measured as running continuously and the beam as the portion below the slab.

## 817 RATE

The contract unit rate for concrete shall include the cost of all materials, labour, tools and plant and equipment required for mixing, transporting, placing in position, vibrating and compacting, finishing and curing as per this Section or as directed by the Engineer, including all other incidental expenses, sampling, testing, quality assurance, supervision for producing concrete of specified strength to complete the structure or its components as shown on the drawings and these Specifications. The contract unit rate shall also include the cost of making, providing, fixing and removing of all form work required for completion of concrete work as per Section 900 of these Specifications.

The Contractor shall pay a discount over the contract unit rate as determined by the Engineer in case concrete is dificient in compressive strength but within acceptable limits.

For deficiency in compressive strength of concrete, when accepted by the Engineer, the reduction in rate shall be applied as under:

$$\text{Percent reduction} = \frac{(\text{Specified Strength-Observed Strength}) \times 100}{\text{Specified Strength}}$$

# 900

# FORMWORK AND SURFACE FINISH FOR STRUCTURES

## 901 SCOPE

Formwork shall include all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support. The design, erection and removal of formwork shall conform to IRC:87 "Guidelines for Design and Erection of Falsework for Road Bridges" and these Specifications.

## 902 MATERIALS

**902.1** All materials shall comply with the requirements of IRC:87. Materials and components used for formwork shall be examined for damage or excessive deterioration before use/re-use and shall be used only if found suitable after necessary repairs. In case of timber formwork, the inspection shall not only cover physical damages but also signs of attacks by decay, rot or insect attack or the development of spilts.

**902.2** Forms shall be constructed with metal or timber. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolts should be countersunk. The use of approved internal steel ties or steel or plastic spacers shall be permitted. Structural steel tubes used as support for forms shall have a minimum wall thickness of 4 mm. Other materials conforming to the requirements of IRC:87 are also permitted to be used with prior approval of the Engineer.

## 903 DESIGN OF FORMWORK

**903.1** The Contractor shall furnish the design and drawing of complete formwork (i.e., the forms as well as their supports) for approval of the Engineer before any erection is taken up. If proprietary system of formwork is used, the Contractor shall furnish detailed information as per IRC:87 to the Engineer for approval.

Notwithstanding any approval or review of drawing and design of formwork by the Engineer, the Contractor shall be entirely responsible for the adequacy and safety for formwork.

**903.2** The design of the formwork shall conform to provisions of IRC:87. It shall ensure that the forms can be conveniently removed without disturbing the concrete. The design shall facilitate proper and safe access to all parts of formwork for inspection.

**903.3** Form panels for abutments, piers and return walls shall not be less than one metre in height and adjusted at the top level only.

**903.4** If steel built up columns are used as supports and are placed on concrete bed, the columns will be fixed to concrete bedding by suitably designed steel plates which shall be bolted to concrete block. These columns shall be extended by bolting flats or angles and not by welding steel bars out side.

Timber planks may be used to make up height difference upto 50 mm by using only single plank. For difference in height more than 50 mm and upto 200 mm, timber block upto 200 mm thick may be used. Height difference more than 200 mm shall not be permitted. Diagonal/ cross bracings shall be with the same size of angles used for columns.

## 904 CONSTRUCTION OPERATIONS

**904.1** Forms for concrete shall be made of metal or timber suitably aligned and be of substantial and rigid construction, true to shape and dimensions shown on the drawings. Where metal forms are used, all bolts and rivets shall be countersunk and well ground to provide a smooth, plain surface. Where timber is used it shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may spoil the surface of concrete. For exposed concrete faces, timber for shuttering shall be wrought on all faces in contact with concrete.

**904.2** Forms shall be mortar-tight and shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressure, ramming and vibration, without deflection from the prescribed lines occurring during and after placing the concrete. Screw jacks or hard-wood wedges where required shall be provided to make up any settlement in the formwork either before or during the placing of concrete.

**904.3** Suitable camber shall be provided in horizontal members of structure to counteract the effects of any deflection so that the deflection of members in formwork is limited by the tolerances specified in permanent works. The formwork shall be so fixed as to provide for such camber.

904.4 Forms shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections.

## 905 FORMED SURFACES AND FINISH

The formwork shall be lined with a proven material, following manufacturer's recommendations and approved by the Engineer so as to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and so joined and fixed to its backing as not to impart any blemishes. It shall be of the same type and obtained from only one source throughout for the construction of any particular component of structure. The contractor shall make good any imperfections in the resulting finish by approved material or rubbing with carborendum stone/grinder. No cement grouting or cement mortar plastering of the exposed concrete surfaces shall be permissible. Internal ties and embedded metal parts will be allowed only with prior specific approval of the Engineer.

## 906 PREPARATION OF FORMWORK BEFORE CONCRETING

**906.1** The inside surfaces of forms shall, except in the case of permanent formwork, be coated with a release agent supplied by approved manufacturer or of an approved material to prevent adhesion of concrete to the formwork. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come into contact with any reinforcement. Different release agents shall not be used in formwork for concrete which will be visible in the finished works. The stains caused by lubricants shall be removed by grinding with carborendum stone. (Burnt mobil oil shall not be used as a lubricant).

**906.2** The formwork shall be constructed with designed precamber to the soffit to allow for deflection of the formwork to ensure that levels of soffit of permanent structure shall conform to those shown in the drawing. The calculated deflection of unsupported areas of form faces shall not exceed 3 mm or 0.003 of the span whichever is less.

**906.3** Formwork shall be tight enough to prevent escape of cement slurry during compaction with vibrators. Laminated tar paper or similar sealants shall be used as per manufacturer's recommendations.

**906.4** All forms shall be thoroughly cleaned immediately before concreting.

**906.5** The contractor shall give the Engineer due notice before placing any concrete in the forms to permit him to inspect and approve the formwork and coat of release agent. However, such inspection shall not relieve the contractor of his responsibility for safety of formwork, men, machinery, materials and finish or tolerances of concrete.

**906.6** Where field operations are controlled by strength tests of concrete, the removal of the load-supporting or soffit forms may commence when concrete has attained strength equal to at least twice the stress to which the concrete will be subjected at the time of striking props including the effect of any further addition of loads. When field operations are not controlled by strength tests of concrete, the vertical forms of beams, columns and walls may be removed after two days. The props of beams may be removed after 21 days.

## 907 WORKMANSHIP

**907.1** The formwork shall be robust and strong and the joints shall be leak-proof.

**907.2** Balli of diameter less than 100 mm for height not more than 4 m without any joint in ballies may also be used as staging. Staging must have cross bracings and diagonal bracings in both directions. Bracing should be of minimum 75 mm dia ballies. Staging shall be provided with designed base plate resting on firm strata.

**907.3** The number of joints in the formwork shall be kept to a minimum by using large size panels. The design shall provide for proper "soldiers" to facilitate alignment. All joints shall be leak proof and must be properly sealed by using PVC JOINT sealing tapes, foam rubber or PVC T-section to prevent leakage from green concrete.

**907.4** Clamps of adequate strength shall be used to hold the forms together. Where use of nails is unavoidable, minimum number of double headed nails shall be used and these shall be left projecting so that they can be withdrawn easily.

**907.5** Chamfers or fillets of minimum size of 25 mm x 25 mm shall be provided at all angles of the formwork to avoid sharp corners. The chamfers, beveled edges and mouldings shall be made in the formwork itself. Opening for fixtures and other fittings shall be provided in the shuttering as shown in drawings or as directed by the Engineer.

**907.6** Shuttering for walls, sloping members and thin sections of considerable height shall be provided with temporary openings to permit inspection and cleaning out before placing of concrete.

**907.7** The formwork shall be so made as to produce a finished concrete true to shape, line and levels and dimensions as shown on the drawings, subject to the tolerances specified in respective sections of these Specifications.

**907.8** Where metal forms are used, all bolts and rivets shall be countersunk and well ground to provide a smooth, plain surface. Where timber is used, it shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may mar the surface of concrete.

**907.9** Forms shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressure, ramming and vibration during and after placing the concrete. Screw jacks or hard wood wedges where required shall be provided to make up any settlement in the formwork either before or during the placing of concrete.

**907.10** The formwork and plates in contact with concrete shall be coated with an approved release agent that will effectively prevent sticking and will not stain the concrete surface. Lubricating machine oils shall be prohibited for use as coating.

**907.11** No centring and shuttering shall be kept on soft or filled up earth.

## 908 REMOVAL OF FORMWORK

**908.1** The scheme for removal of formwork (i.e., de-shuttering and de-centering) shall be planned in advance and furnished to the Engineer for scrutiny and approval. No formwork or any part thereof shall be removed without prior approval of the Engineer.

**908.2** While fixing the time for removal of formwork, due consideration shall be given to the local conditions, character of the structure, the weather and other conditions that influence the setting of concrete and of the materials used in the mix. The period shall be suitably increased in case of temperatures lower than 23°C and for any other conditions tending to delay the setting of concrete.

**908.3** The formwork shall be so removed as not to cause any damage to concrete. Centering shall be gradually and uniformly lowered in such a manner as to permit the concrete to take stresses due to its own weight uniformly and gradually, to avoid any shock or vibration.

**908.4** Formwork shall not be released unless the concrete has achieved strength of at least twice the stress the concrete may be subjected at the time of removal of formwork. When no tests are conducted and where time of removal not specifically approved, the time of removal of formwork (when Ordinary Portland Cement is used without any admixtures at an ambient temperatures exceeding 10°C) shall be as under:

a) Walls, piers, abutments, columns and vertical faces of structural members : 12 to 48 hours as shall be decided by the Engineer.
b) Soffits of slabs (with props left under) : 3 days
c) Props (left under slabs) : 14 days
d) Soffit of girders (with props left under) : 7 days
e) Props (left under girders) : 21 days

**908.5** Where there are re-entrant angles in the concrete sections, the formwork should be removed at these sections as soon as possible after the concrete has set, in order to avoid cracking due to shrinkage of concrete.

**908.6** Where internal metal ties are permitted, they or their removable parts shall be extracted without causing any damage to the concrete and remaining holes filled with cement mortar (1:3). No permanently embedded metal part shall have less than 25 mm cover to the finished concrete surface.

## 909 RE-USE OF FORMWORK

**909.1** When formwork is dismantled, its individual components shall be examined for damage and damaged pieces shall be removed for rectification. Such examination shall always be carried out before being used again. Before re-use, all components shall be cleaned of deposits of soil, concrete or other unwanted materials. Threaded parts shall be oiled after cleaning.

Before re-use of forms, the following actions shall be taken :

i) The contact surfaces of the forms shall be cleaned carefully and dried before applying a release agent.

ii) The form surfaces shall be evenly and thinly coated with release agent. The vertical surface shall be treated before horizontal surface and any excess release agent properly wiped out.

iii) The release agent shall not come in contact with reinforcement or hardened concrete.

**909.2** All bent steel props shall be straightened before re-use. The maximum deviation from straightness is 1/600 of the length. The maximum permissible axial loads in used props shall be reduced after each re-use depending upon their condition. The condition of the timber components plywood and steel shuttering plates shall be examined closely for distortion and defects before re-use.

## 910 PRECAUTIONS

i) The forms may be removed at the earliest opportunity subject to the minimum time for removal of forms at props retained in position.

ii) Where necessary, formwork shall be so arranged that the soffit form, properly supported on props only can be retained in position for such period as may be required by maturing conditions.

iii) Any cut-outs or openings provided in any structural member to facilitate erection of formwork shall be closed with the same grade of concrete as the adjoining structure immediately after removal of formwork ensuring watertight joints. Steel bars fixed in concrete to erect forms should be cut after removal of forms and end finished with mortar or non-corrosive paint.

iv) Provision shall be made for safe access on to and about the formwork at the levels as required.

v) Close watch shall be maintained to check for settlement of formwork during concreting. Any settlement of formwork during concerting shall be promptly rectified.

vi) Water used for curing should not be allowed to stagnate near the base plate supporting the staging and should be properly drained.

## 911 TOLERANCES

Formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings with the tolerances given below :

| | | |
|---|---|---|
| a) | Deviations from the specified dimensions of cross | + 12 mm |
| | section of columns, beams : | - 6 mm |
| b) | Deviations from dimensions of footings/open foundations | |
| i) | Dimensions in plan : | + 50 mm |
| ii) | Eccentricity in plan : 0.02 times the width of the footings in the direction of deviation but not more than 50 mm | - 12 mm |
| iii) | Thickness : ± 0.05 times the specified thickness | |

***Note :*** Tolerance apply to concrete dimensions only, and not to positioning of vertical steel or dowels.

Provisions of Section 1800 shall also apply.

## 912 MEASUREMENTS FOR PAYMENT

**912.1** Where it is specifically stipulated in the contract that the formwork shall be paid for separately, formwork shall be measured in square metres of the area of concrete surface, which is in contact with formwork.

**912.2** Where it is not specifically stated in the contract or description of the item of work that formwork shall be paid for separately, the rate of the Cement Concrete items shall be deemed to include the cost of all formwork.

## 913 RATE

The unit rate of the plain concrete or reinforced concrete as defined in respective sections including box-sections shall be deemed to cover the costs of all formwork, including cost of all materials, labour, tools and plant required for design, construction and removal of formwork and supervision as described in this section including properly supporting the members until the concrete is cured, set and hardened as required.

Where the contract unit rate for formwork is specifically provided as a separate item, it shall include the cost of all materials, labour, tools and plant required for design, construction and removal of formwork and supervision as described in this Section including properly supporting the members until the concrete is cured, set and hardened as required.

## 1000

# STEEL REINFORCEMENT, PRESTRESSING AND STRUCTURAL STEEL

## 1001 STEEL REINFORCEMENT (UNTENSIONED)

### 1001.1 Scope

This work shall consist of furnishing and placing coated or uncoated mild steel or high strength deformed reinforcement bars (untensioned) of the shape and dimensions shown on the drawings and conforming to these Specifications or as approved by the Engineer.

### 1001.2 General

Steel for reinforcement shall meet the requirements of Section 2000 of these Specifications.

Reinforcements may be either mild steel/medium tensile steel or high strength deformed bars. They may be uncoated or coated with epoxy.

### 1001.3 Protection of Reinforcement

Uncoated reinforcing steel shall be protected from rusting or chloride contamination. Reinforcements shall be free from rust, mortar, loose mill scale, grease, oil or paints. This may be ensured either by using reinforcement fresh from the factory or thoroughly cleaning all reinforcement to remove rust using any suitable method such as sand blasting, mechanical wire brushing, etc., as directed by the Engineer. Reinforcements shall be stored on blocks, racks or platforms and above the ground in a clean and dry condition and shall be suitably marked to facilitate inspection and identification.

Portions of uncoated reinforcing steel and dowels projecting from concrete shall be protected within one week after initial placing of concrete with a brush coat of neat cement mixed with water to a consistency of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before placing of the adjacent pour of concrete. Coated reinforcing steel shall be protected against damage to the coating. If the coating on the bars is damaged during transportation or handling and cannot be repaired, the same shall be rejected.

### 1001.4 Bending of Reinforcement

Bar bending schedule shall be furnished by the Contractor and got approved from the Engineer before start of work.

Reinforcing steel shall conform to the dimensions and shapes given in the approved from Bar Bending Schedules.

Bars shall be bent cold to the specified shape and dimensions or as directed by the Engineer using a proper bar bender, operated by hand or power to obtain the correct radii of bends and shape.

Bars shall not be bent or straightened in a manner that will damage the parent material or the coating.

Bars bent during transport or handling shall be straightened before being used on work and shall not be heated to facilitate straightening.

## 1001.5 Placing of Reinforcement

a) The reinforcement cage should generally be fabricated in the yard at ground level and then shifted and placed in position. The reinforcement shall be placed strictly in accordance with the drawings and shall be assembled in position only when the structure is otherwise ready for placing of concrete. Prolonged time gap between assembling of reinforcement and casting of concrete, which may result in rust formation on the surface, shall not be permitted.

b) Reinforcement bars shall be placed accurately in position as shown on the drawings. The bars, crossing one another shall be tied together at every intersection with binding wire (annealed), conforming to IS:280 to make the skeleton of the reinforcement rigid such that the reinforcement does not get displaced during placing of concrete, or any other operation. The diameter of binding wire shall not be less than one mm.

c) Bars shall be kept in position usually by the following methods:

   i) In case of beam and slab construction, industrially produced polymer cover blocks of thickness equal to the specified cover shall be placed between the bars and formwork subject to satisfactory evidence that the polymer composition is not harmful to concrete and reinforcement. Cover blocks made of concrete may be permitted by the Engineer, provided they have the same strength and specification as those of the member.

   ii) In case of dowels for columns and walls, the vertical reinforcement shall be kept in position by means of timber templates with slots cut in them accurately, or with cover blocks tied to the reinforcement. Timber templates shall be removed after the concreting has progressed upto a level just below their location.

   iii) Layers of reinforcements shall be separated by spacer bars at approximately one metre intervals. The minimum diameter of spacer bars shall be 12 mm or equal to maximum size of main reinforcement or maximum size of coarse aggregate, whichever is greater. Horizontal reinforcement shall not be allowed to sag between supports.

   iv) Necessary stays, blocks, metal chairs, spacers, metal hangers, supporting wires etc. or other subsidiary reinforcement shall be provided to fix the reinforcements firmly in its correct position.

   v) Use of pebbles, broken stone, metal pipe, brick, mortar or wooden blocks etc., as devices for positioning reinforcement shall not be permitted.

d) Placing and fixing of reinforcement shall be inspected and approved by the Engineer before concrete is deposited.

## 1001.6 Bar Splices

### 1001.6.1 *Lapping*

All reinforcement shall be furnished in full lengths as indicated on the drawing. No splicing of bars, except where shown on the drawing, shall be permitted without approval of the Engineer. The lengths of the splice shall be as indicated on the drawing or as approved by the Engineer. Where practicable, overlapping bars shall not touch each other, and shall be kept apart by 25 mm or 1.25 times the maximum size of coarse aggregate, whichever is greater. If this is not feasible, overlapping bars shall be bound with annealed steel binding wire not less than one mm diameter and twisted tight in such a manner as to maintain minimum clear cover to the reinforcement from the concrete surface. Lapped splices shall be staggered or located at points, along the span where stresses are low.

### 1001.6.2 *Welding*

*1001.6.2.1* Splicing by welding of reinforcement will be permitted only if detailed on the drawing or approved by the Engineer. Weld shall develop an ultimate strength equal to or greater than that of the bars connected.

*1001.6.2.2* While welding may be permitted for mild steel reinforcing bars conforming to IS:432, welding of deformed bars conforming to IS:1786 shall in general be prohibited. Welding may be permitted in case of bars of grade other than Fe 240 including special welding grade of Fe 415 grade bars conforming to IS:1786, for which necessary chemical analysis has been secured and the Carbon Equivalent (CE) calculated from the chemical composition using the formula :

$$CE = C + \frac{Mn}{6} + \frac{Cr+Mg+V}{5} + \frac{Ni+Cu}{15}$$

is 0.4 or less.

*1001.6.2.3* The method of welding shall conform to IS:2751 and IS:9417 and to any supplemental specifications to the satisfaction of the Engineer.

Welding may be carried out by metal arc welding process. Oxy-acetelene welding shall not be permissible. Any other process may be used subject to the approval of the Engineer and necessary additional requirements to ensure satisfactory joint performance. Precautions on overheating, choice of electrode, selection of correct current in arc welding etc., should be strictly observed.

All bars shall be butt welded except for smaller diameter bars (diameter of less than 20 mm) which may be lap welded. Single-V or Double-V butt joints may generally be used. For vertical bars, single bevel or double bevel joints may be used.

Welded joints shall be located well away from bends and shall be not less than twice the bar diameter away from a bend.

Generally, shop welding in controlled conditions is to be preferred, where feasible. Site welding where necessary shall, however, be permitted when the facilities, equipment, process, consumables, operators, welding procedure are adequate to produce and maintain uniform quality at par with that attainable in shop welding to the satisfaction of the Engineer.

Joint welding procedures which are to be employed shall invariably be established by a procedure specification. All welders and welding operators to be employed shall be qualified by tests prescribed in IS:2751. Inspection of welds shall conform to IS:822 and destructive or non-destructive testing may be undertaken when deemed necessary. Joints with weld defects detected by visual inspection or dimensional check inspection shall not be accepted.

Suitable means shall be provided for holding the bars securely in position during welding. It must be ensured that no voids are left in welding. When welding is done in 2 or 3 stages, previous surface shall be cleaned properly. Bars shall be cleaned of all loose scale, rust, grease, paint and other foreign matter before carrying out welding. Only competent and experienced welders shall be employed on the work with the approval of the Engineer. No welding shall be done on coated bars.

MS electrodes used for welding shall conform to IS:814.

*1001.6.2.4* Welded joints shall preferably be located at points where steel will not be subject to more than 75 percent of the maximum permissible stresses and welds so staggered that at any one section, not more than 20 percent of the bars are welded.

*1001.6.2.5* Welded pieces of reinforcement shall be tested. Specimens shall be taken from the site and the number and frequency of tests shall be as directed by the Engineer.

## 1001.7 Coating of Reinforcing Bars

### 1001.7.1 *Fusion Bonded Epoxy Coated Reinforcement*

In marine environment where the rate of corrosion is greater than 0.25 mm per year or for bridges located within a distance 15 km from the sea or creek, fusion bonded epoxy coated reinforcement conforming to IS:13620 or other international standards only shall be used in reinforced concrete or prestressed concrete components of bridges. The location of the source of supply of the coated bars shall be such as to ensure that they are not transported for a distance of more than 300 km.

Additional requirements for the use of such reinforcement bars are given below :

a) Patch up materials shall be procured in sealed containers with certificate from the agency who has supplied the fusion bonded epoxy bars.

b) PVC coated GI binding wires of 18G shall only be used in conjunction with fusion bonded epoxy bars.

c) Chairs for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.

d) The cut ends and damaged portions shall be touched up with repair patch up material.

e) The bars shall be cut by saw-cutting rather than flame cutting.

f) While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves.

g) The coated steel shall not be directly exposed to sun rays or rains and shall be protected with opaque polyethylene sheets or such other approved materials.

h) While concreting, the workmen or trolley shall not directly move on coated bars but can move on wooden planks placed on the bars.

### 1001.7.2 *Hot Dipped Galvanised Bars*

Hot dipped galvanised reinforcing steel shall be provided wherever specified. The coating shall conform to IS:12594.

## 1001.8 Testing and Acceptance

The material shall be tested in accordance with relevant IS specifications and necessary test certificates shall be furnished. Additional tests, if required, will be got carried out by the Contractor at his own cost. Provision of Section 1800 shall also apply.

The fabrication, furnishing and placing of reinforcement shall be in accordance with these specifications and shall be checked and accepted by the Engineer.

Manufacturer's test certificate regarding compliance with the Indian Standards for each lot of steel shall be obtained and submitted to the Engineer. If required by the Engineer, the Contractor shall carry out confirmatory tests in the presence of a person authorized by the Engineer. Cost of these tests shall be borne by the Contractor. The sampling and testing procedure shall be as laid down in IS:1786. If any test piece selected from a lot fails, no retesting shall be done and lot shall be rejected.

## 1001.9 Measurement for Payment

Reinforcement shall be measured in length including hooks, if any, separately for different diameters as actually used in work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in tonnes on the basis of IS:1732. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

## 1001.10 Rate

The contract unit rate for coated/uncoated reinforcement shall cover the cost of material, fabricating, royalty, transporting, storing, bending, placing, binding and fixing in position as shown on the drawings as per these specifications and as directed by the Engineer, including all labour, equipment, supplies, incidentals, sampling, testing and supervision.

The unit rate for coated reinforcement shall be deemed to also include cost of all material, labour, tools and plant, royalty, transportation and expertise required to carry out the work. The rate shall also cover sampling, testing and supervision required for the work.

## 1002 STRUCTURAL STEEL

### 1002.1 Scope

This work shall include furnishing, fabricating, transporting, erecting and painting structural steel, rivet steel, cast steel, steel forgings, cast iron and other incidental metal construction of the kind, size and quantity in conformity with the drawings and these Specifications or as directed by the Engineer.

### 1002.2 General

General requirements relating to the supply of material shall conform to the requirements of IS:1387, for the purpose of which the supplier shall be the Contractor and the purchaser shall be the Engineer.

Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth and uniform finish, and shall be straightened in the mill before shipment. It shall also be free from loose mill scale, rust, pits or other defects affecting its strength and durability.

The acceptance of any material on inspection at the rolling mill, foundry or fabricating plant where material for the work is manufactured, shall not be a bar to its subsequent rejection, if found defective.

Unless otherwise specified, high tensile steel rivets conforming to IS:1149 shall be used only for members of high tensile steel conforming to IS:961 and shall not be used for members of mild steel.

Unless otherwise specified, bolted connection of structural joints using high tensile friction grip bolts shall comply with requirements of IS:4000.

Cast iron shall not be used in any part of the bridge structure, except where it is subject to direct compression.

### 1002.3 Materials

**1002.3.1** All materials shall conform to Section 2000 of these Specifications. Special requirements are given below:

Mild steel for bolts and nuts shall conform to IS:226 but have a minimum tensile strength of 44 kg/sq.mm and minimum percentage elongation of 14. High tensile steel for bolts and nuts shall conform to IS:961 but with a minimum tensile strength of 58 kg/sq.mm. Use of high strength friction grip bolts shall be permitted only on satisfactory evidence of performance to the requirements (not covered by these Specifications) specified by the Engineer or as laid down in special provisions.

For cast steel, the yield stress shall be determined and shall not be less than 50 percent of the minimum tensile strength.

Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or malleable cast iron.

Parallel barrel drifts shall have a tensile strength not less than 55 kg/sq.mm with elongation of not less than 20 percent measured on a gauge length of $4 \sqrt{So}$ (So = cross-sectional area).

**1002.3.2** Materials for castings and forgings, fasteners and welding consumables shall be as under:

### *1002.3.2.1 Castings and forgings*

Steel castings and forgings shall comply with the requirements of the following Indian Standards, as appropriate :

| | |
|---|---|
| IS:1030 | Carbon Steel Castings for General Engineering purposes |
| IS:1875 | Carbon Steel Billets, blooms, slabs, bars for forgings |
| IS:2004 | Carbon Steel Forgings for General Engineering purposes |
| IS:2644 | High Tensile Steel Castings |
| IS:2708 | 1.5 percent Manganese Steel Castings |
| IS:4367 | Alloy and tool steel forgings for general industrial use |

### *1002.3.2.2 Fasteners*

Bolts, nuts washers and rivets shall comply with the following or relevant Indian Standards as appropriate:

| | |
|---|---|
| IS:1148 | Hot rolled rivet bars (up to 40 mm dia) for structural purposes |
| IS:1149 | High tensile steel rivet bars for structural purposes |
| IS:1929 | Hot forged steel rivets for hot closing (12-36 mm dia) |
| IS:2155 | Cold forged steel rivets for hot closing (6-16 mm dia) |
| IS:1363 | Hexagon head bolts, screw and nuts product grade C |
| IS:1364 | Hexagon head bolts, screw and nuts product grade A and B |
| IS:1367 | Technical supply conditions for threaded steel fastener (Parts 1 to 18) |
| IS:3640 | Hexagon fit bolts |
| IS:3757 | High tensile friction grip bolts |
| IS:4000 | High strength bolts in steel structures |
| IS:6623 | High strength structural nuts |
| IS:6639 | Hexagon bolts for steel structure |
| IS:5624 | Foundation bolts |
| IS:7002 | Prevailing torque type steel hexagon lock nuts |
| IS:5369 | Plain washers and lock washers – general requirements |

| | |
|---|---|
| IS:5370 | Plain washers with outside dia = 3 X inside dia |
| IS:5372 | Taper washers for channels (ISMC) |
| IS:5374 | Taper Washers for I beams (ISMB) |
| IS:6610 | Heavy washers for steel structures |
| IS:6649 | Hardened and tempered washers for high strength structural bolts and nuts. |

*1002.3.2.3* *Welding consumables*

Welding consumables shall comply with the following Indian Standards as appropriate:

| | |
|---|---|
| IS:814 (Part 1) | Covered Electrodes for Metal Arc Welding of Structural steel for welding other than sheets |
| IS:814 (Part 2) | For welding sheets |
| IS:1395 | Low and medium alloy steel covered electrodes for manual Metal Arc Welding |
| IS:3613 | Acceptance Tests for wire flux combinations for submerged arc welding of structural steel |
| IS:7280 | Bare wire electrodes for gas shielded arc welding of structural steel |
| IS:6419 | Welding rods and bare electrodes for gas shielded arc welding of structural steel |
| IS:6560 | Molybdenum and chromium-molybdenum low alloy steel welding rods and bare electrodes for gas shielded arc welding |

**1002.3.3** Corrosion resistant steel to be used in aggressive environment shall be low-alloy steels containing a total of 1 percent to 2 percent alloys, in particular copper, chromium, nickel and phosphorous.

### 1002.3 Paints

All materials for paints and enamels shall conform to the requirements specified on the drawings or other special provisions laid down by the Engineer.

The type of paints which can be used shall be as follows :

a) Ordinary i.e. paints based on drying oils, alkyd resin, modified alkyd resin, phenolic vamish epoxy

b) Chemical Resistant – one pack type (ready for use) or two pack type (mixed before use).

c) Vinyl

d) Chlorinated rubber

e) Bituminous - (IS:9862)

f) Epoxy - (IS:14925)

g) Polyurethane - (IS:13759)

h) Zinc rich - (IS:14589)

Unless otherwise specified, paints shall conform to the relevant Indian Standards. Paints shall be tested for the following qualities as per Specifications given in the relevant IS codes:

- Weight (for 10 litres of paint, thoroughly mixed)
- Drying time
- Consistency
- Dry thickness and rate of consumption

## 1003 FABRICATION

### 1003.1 General

All work shall be in accordance with the drawings and as per these Specifications. It shall be ensured that all parts of an assembly fit accurately together. All members shall carry mark number and item number and, if required, serial number.

Templates, jigs and other appliances used for ensuring the accuracy of the work shall be of mild steel; where specially required, these shall be bushed with hard steel. All measurements shall be made by means of steel tape or other device properly calibrated. Where bridge materials have been used as templates for drilling, these shall be inspected and approved by the Engineer before they are used in the finished structure.

All structural steel members and parts shall have straight edges and blunt surfaces. They shall also be free from twist. If necessary, they shall be straightened or flattened by pressure unless they are required to be of curvilinear forms. Pressure applied for straightening or flattening shall be such as would not damage the materials. Hammering shall not be permitted. Adjacent surfaces or edges shall be in close contact or at uniform distance throughout.

The Contractor shall submit his programme of work to the Engineer for his approval at least 15 days before the commencement of fabrication. This programme shall include the proposed system of identification and erection marks together with complete details of fabrication and welding procedures.

The Contractor shall prepare shop drawings for fabrication of any member and obtain approval of the Engineer before the start of work. Complete information regarding the location, type, size and extent of all welds shall be clearly shown on the shop drawings. These drawings shall distinguish between shop and field welds.

### 1003.2 Preparation of Edges and Ends

All structural steel parts, where required, shall be sheared, cropped, sawn or flame cut and ground accurately to the required dimension and shape.

End/edge planing and cutting shall be done by any one of the following prescribed methods or left as rolled:

a) Shearing, cropping, sawing, machining, machine flame cutting.

b) Hand flame cutting with subsequent grinding to a smooth edge.

Sheared edges of plate not more that 16 mm thick, which are for secondary use such as stiffeners and gussets, shall be subsequently ground to smooth profile.

If ends of stiffeners are required to be fitted, they shall be ground, so that the maximum gap over 60 percent of the contact area does not exceed 0.25 mm.

Where flame cutting or shearing is done, at least one of the following requirements shall be satisfied.

a) The cut edge is not subjected to applied stress.

b) The edge is incorporated in weld.

c) The hardness of cut edge does not exceed 350 HV30.

d) The material is removed from edge to the extent of 2 mm or minimum necessary, so that the hardness is less than 350 HV 30.

e) Edge is suitably heat treated by approved method to the satisfaction of the Engineer and it is shown by dye penetrant or magnetic particle test that cracks have not developed.

f) Thickness of plate is less than 40 mm for machine flame cutting of materials conforming to IS:226 and IS:2062. The requirement of hardness below 350 HV 30 of flame cut edges shall be specified by the Engineer.

The flame cut edges shall be ground or machined over and above the requirements in (a) to (f), wherever specified by the Engineer.

Where machining for edge preparation in butt joint is specified, the ends shall be machined after the members have been fabricated.

Outside edges of plate and section, which are prone to corrosion shall be smoothened by grinding or filing.

In the case of high tensile steel, at least 6 mm of the material from the flame cut edge shall be removed by machining.

Longitudinal edges of all plates and cover plates in plate girders and built-up members shall be machined except in the following cases:

a) Rolled edges of single universal plates or flats

b) Covers to single flange plates.

c) Edges of single plates in compression and edges of single plates 25 mm or less thick, in tension, where machine flame cutting is acceptable.

d) Edges of single shaped plates over 2 mm thick not capable of being machined by ordinary method, which may be machine flame cut and the end surface ground.

e) Edges of universal plates or flats of the same nominal width used in tiers, if so authorized by the Engineer.

All edges of splice and gusset plates 12 mm thick and over, shall be machined and those less than 12 mm thick shall be sheared and ground.

The ends of plates and sections forming the main components of plate girders or of built-up members shall be machined, machine flame cut, sawn or hand flame cut and ground.

Where ends of stiffeners are required to be fitted, they shall be machined, machine flame cut, sawn, sheared and ground, or hand flame cut and ground.

The ends of lacing bar shall be rounded unless otherwise specified.

Other edges and ends of mild steel parts shall be sheared and any burrs at edges shall be removed.

### 1003.3 Preparation of Holes

#### 1003.3.1 *Drilling and punching*

Holes for rivets, black bolts, high strength bolts and countersunk bolts/rivets (excluding close tolerance and turn fitted bolts) shall be either punched or drilled. For bolts/rivets less than 25 mm dia, the diameter of holes shall be 1.5 mm larger while for those of 25 mm dia or more, the diameter of holes shall be 2 mm larger.

All holes shall be drilled except for secondary members such as floor plates, hand rails etc. Members which do not carry the main load can be punched subject to the thickness of member not exceeding 12 mm for material conforming to IS:226.

Holes through material of more than one thickness or through main material thickness exceeding 20 mm for steel conforming to IS:2062 or 16 mm for steel conforming to IS:961, IS:8500, shall either be sub-drilled or sub-punched to a diameter of 3 mm less than the required size and then reamed to the required size. The reaming of material more than one thickness shall be done after assembly.

Where several plates or sections form a compound member, they shall, where practicable, be firmly connected together by clamps or tacking bolts and the holes shall be drilled through the group in one operation. Alternatively, and in the case of repetition work, the plates and sections may be drilled separately from jigs and templates. Jigs and templates shall be checked at least once after every 25 operations. All burrs shall be removed.

In the case of repetition of spans, the erection of every span shall not be insisted upon, except where close tolerance or turned bolts are used, provided that methods are adopted to ensure strict interchangeability. In such cases, one span in ten or any number less than ten of each type shall be erected from pieces selected at random by the Engineer and should there be any failure of the pieces to fit, all similar spans shall be erected complete. In the event of spans being proved completely interchangeable, all corresponding parts shall carry the same mark so that sorting of the materials at site is facilitated.

### 1003.3.2 *Block drilling*

Where the number of plates to be riveted exceeds three or the total thickness is 90 mm or more, the rivet holes, unless they have been drilled through steel bushed jigs, shall be drilled out in place 3 mm all round after assembling. In such cases, the work shall be tightly bolted together.

### 1003.3.3 *Size of holes*

The sizes of holes in millimetres are given in **Table 1000.1**.

**Table 1000.1 Diameter of Holes for Rivets**

| Nominal dia of Rivets (mm) | Dia of Holes (mm) |
|---|---|
| 12 | 13.5 |
| 14 | 15.5 |
| 16 | 17.5 |
| 18 | 19.5 |
| 20 | 21.5 |
| 22 | 23.5 |
| 24 | 25.5 |
| 27 | 29.0 |
| 30 | 32.0 |
| 33 | 35.0 |

### 1003.3.4 *Close tolerance bolts and barrel bolts*

For close tolerance or turn fitted bolts, the diameter of the holes shall be equal to the nominal diameter of the bolt shank minus 0.15 mm to 0.0 mm.

The members to be connected with close tolerance or turn fitted bolts shall be firmly held together by service bolts or clamped and drilled through all thicknesses in one operation and subsequently reamed to required size within specified limit of accuracy as specified in IS:919 tolerance grade H8.

The holes not drilled through all thicknesses in one operation shall be drilled to smaller size and reamed after assembly.

### 1003.3.5 *Holes for high strength friction grip bolts*

All holes shall be drilled after removal of burrs. Where the number of plies in the grip does not exceed three, the diameter of holes shall be 1.6 mm larger than those of bolts. Where the number of plies in the grip exceeds three, the diameter of holes shall be as follows:

- in outer plies 1.6 mm larger than dia of bolts
- in inner plies not less than 1.6 mm and not more than 3.2 mm larger than dia of bolts unless otherwise specified by the Engineer.

### 1003.3.6 *Removal of burrs*

The work shall be taken apart after drilling and all burrs left by drilling and the sharp edges of all rivet holes completely removed.

## 1003.4 Rivets and Riveting

The diameter of rivets shown on the drawings shall be the size before heating. Each rivet shall be of sufficient length to form a head of the standard dimensions as given in IS handbook on Steel Sections, Part I. The underside of the head shall be free from burrs.

When countersunk head is required, the head shall fill the countersunk hole and projection after countersinking shall be ground off wherever necessary. The included angle of the head shall be as follows :

a) For plates over 14 mm thickness-90 degrees

b) For plates upto and including 14 mm thickness-120 degrees

The tolerance on the diameter of rivets shall be in accordance with IS:1148 for mild steel rivets and IS:1149 for high tensile steel rivets. Unless otherwise specified, the tolerance shall be minus.

Rivets shall be driven when hot so as to fill the hole as completely as possible.

Mild steel rivets shall be heated uniformly to a light cherry red colour between 650°C and 700°C for hydraulic riveting and orange colour for pneumatic riveting. They shall be red hot from head to the point when inserted and shall be upset in its entire length so as to fill the hole as completely as possible when hot. After being heated and before being inserted in the hole, the rivet shall be made free from scale by striking it on a hard surface.

Wherever possible, the rivets shall be machine driven, preferably by direct acting riveters. The driving pressure shall be maintained on the rivets for a short time after the upsetting is completed. High tensile steel rivets shall be heated upto 1100°C. Any rivet whose point is heated more than prescribed, shall not be driven.

Where flush surface is required, any projecting metal shall be chipped or ground off.

Before riveting is commenced, all work shall be properly bolted up so that the various sections and plates are in close contact throughout. Drifts shall only be used for drawing the work into position and shall not be used to such an extent as to distort the holes. Drifts of a size larger than the nominal diameter of the hole shall not be used. The riveting shall be done by hydraulic or pneumatic machine unless otherwise specified by the Engineer.

Driven rivets, when struck sharply on the head by a quarter pound rivet testing hammer, shall be free from movement and vibrations. Assembled riveted joint surfaces, including those adjacent to the rivet heads, shall be free from, dirt, loose scale, burrs, other foreign materials and defects that would prevent solid seating of parts.

All loose or burnt rivets and rivets with cracked or badly formed defective heads or heads which are unduly eccentric with the shanks, shall be removed and replaced. In removing rivets, the head shall be sheared off and the rivet punched out so as not to damage the adjacent metal. If necessary, the rivets shall be drilled out. Recupping or recaulking shall not be permitted. The parts not completely riveted in the shop shall be secured by bolts to prevent damage during transport and handling.

## 1003.5 Bolts, Nuts and Washers

### 1003.5.1 *Black bolts (black all over)*

Black bolts are forged bolts in which the shanks, heads and nuts do not receive any further treatment except cutting of screw threads. They shall be true to shape and size and shall have the standard dimensions as shown on the drawings.

### 1003.5.2 *Close tolerance bolts*

Close tolerance bolts shall be faced under the head and turned on the shank.

### 1003.5.3 *Turned barrel bolts*

The diameter of the screwed portion of turned barrel bolts shall be 1.5 mm smaller than the diameter of the barrel unless otherwise specified by the Engineer. The diameter of the bolts as given on the drawing shall be the nominal diameter of the barrel. The length of the barrel shall be such that it bears fully on all the parts connected. The threaded portion of each bolt shall project through the nut by at least one thread. Faces of heads and nuts bearing on steel work shall be machined.

### 1003.5.4 *High strength friction bolts and bolted connections*

The general requirement shall be as per relevant IS Specifications mentioned in Clause 502.4 of IRC:24. Unless otherwise specified by the Engineer, bolted connections of structural joints using high tensile friction grip bolts shall comply with requirements mentioned in IS:4000.

### 1003.5.5 *Washers*

In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a steel washer under the nut of sufficient thickness to avoid any threaded portion of the bolt being within the thickness of the parts bolted together and to prevent the nut when screwed up, from bearing on the bolt.

For close tolerance or turned barrel bolts, steel washers whose faces give a true bearing shall be provided under the nut. The washer shall have a hole diameter not less than 1.5 mm larger than the barrel and thickness not less than 6 mm so that the nut, when screwed up, will not bear on the shoulder of the bolt.

Taper washer, with correct angle of taper, shall be provided under all heads and nuts bearing on bevelled surfaces.

Spring washers may be used under nuts to prevent slackening of the nuts when excessive vibrations occur.

Where the heads or nuts bear on timber, square washers having a length of each side not less than three times the diameter of bolts or round washers having a diameter of 3½ times the diameter of bolts and with a thickness not less than one quarter of diameter, shall be provided.

### **1003.5.6** *Studs*

Ordinary studs may be used for holding parts together, the holes in one of the parts being tapped to take the thread of the stud. Countersunk studs may be used for making connections where the surfaces are required to be clear of all obstruction, such as protruding heads of bolts or rivets. Studs may also be welded on the steel work in the positions required.

### **1003.5.7** *Service bolts*

Service bolts shall have the same clearance as black bolts and where it is required that there should be no movement prior to final riveting, sufficient drifts or close tolerance bolts shall be used to locate the work.

### **1003.5.8** *Tightening bolts*

Bolted connection joints with black bolts and high strength bolts shall be inspected for compliance of codal requirements.

The Engineer shall observe the installation and tightening of bolts to ensure that correct tightening procedure is used and all bolts are tightened. Regardless of tightening method used, tightening of bolts in a joint should commence at the most rigidly fixed or stiffest point and progress towards the free edges, both in initial snugging and in final tightening.

The tightness of bolts in connection shall be checked by inspection wrench, which can be torque wrench, power wrench or calibrated wrench.

Tightness of 10 percent bolts, but not less than two bolts, selected at random in each connection shall be checked by applying inspection torque. If no nut or bolt head is turned by this application, connection can be accepted as properly tightened, but If any nut or head has turned, all bolts shall be checked and, if necessary, re-tightened.

### **1003.5.9** *Drifts*

The barrel shall be drawn or machined to the required diameter for a length of not less than one diameter over the combined thickness of the metal through which the drifts have to pass. The diameter of the parallel barrel shall be equal to the nominal diameter of the hole subject to a tolerance of +0 mm and - 0.125 mm. Both ends of the drift for a length equal to 1½ times the diameter of the parallel portion of the bar, shall be turned down with a taper to a diameter at the end equal to one-half that of parallel portion.

## 1003.6 Pins and Pin Holes

### 1003.6.1 *Pins*

The pins shall be parallel throughout and shall have a smooth surface free from flaws. They shall be of sufficient length to ensure that all parts connected thereby shall have a full bearing on them. Where the ends are threaded, they shall be turned to a smaller diameter at the ends for the thread and shall be provided with a pilot nut, where necessary, to protect the thread when being drawn to place.

Pins more than 175 mm in length or diameter shall be forged and annealed.

### 1003.6.2 *Pin holes*

Pin holes shall be bored true to gauge, smooth, straight at right angles to the axis of the member and parallel with each other, unless otherwise required. The tolerance in the length of tension members from outside to outside of pin holes and of compression members from inside to inside of pin holes shall be one millimeter. In built-up members, the boring shall be done after the members have been riveted or welded.

The specified diameter of the pin hole shall be its minimum diameter. The resulting clearance between the pin and the hole shall not be less than 0.5 mm and not more than 1.0 mm.

## 1003.7 Shop Erection and Match Marking

Before being dispatched, the steel work shall be temporarily erected in the fabrication shop for inspection by the Engineer either wholly or in such portion as the Engineer may require, so that he may be satisfied in respect of both the alignment and fit of all connections. For this purpose, sufficient number of parallel drifts and service bolts tightly screwed up shall be employed. All parts shall fit accurately and be in accordance with the drawings and specifications.

The steel work shall be temporarily assembled at place of fabrication. Assembly shall be of full truss or girder, unless progressive truss or girder assembly, full chord assembly, progressive chord assembly or special complete structure assembly is specified by the Engineer.

The field connections of main members of trusses, arches, continuous beams, spans, bends, plate girders and rigid frame shall be assembled, aligned and accuracy of holes and camber checked by the Engineer. Only thereafter shall reaming of sub-sized holes to specified size, be taken up.

After the work has been passed by the Engineer and before it is dismantled, each part shall be carefully marked for re-erection with distinguishing marks and stamped with durable markings. Drawings showing these markings correctly shall be supplied to the Engineer.

Unloading, handling and storage of steel work as per these Specifications shall be the responsibility of the Contractor. The cost of repairs, removal of rejected material, and transportation of replacement material to the site, shall be borne by the Contractor.

In cases where close tolerance or turned barrel bolts are used and interchangeability is not insisted upon, each span shall be erected and its members marked distinctly.

### 1003.8 Welding

**1003.8.1** All welding shall be done with the prior approval of the Engineer and the workmanship shall conform to the specifications of IS:823 or other relevant Indian Standards as appropriate.

When material thickness is 20 mm or more, special precautions like preheating shall be taken as laid down in IS:823. Surfaces and edges to be welded shall be smooth, uniform and free from fins, tears, cracks and other discontinuities. Surface shall also be free from loose or thick scale, slag rust, moisture, oil and other foreign materials. Surfaces within 50 mm of any weld location shall be free from any paint or other material that may prevent proper welding or cause objectionable fumes during welding.

The general welding procedures including particulars of the preparation of fusion faces for metal arc welding shall be carried out in accordance with IS:9595.

The welding procedures for shop and site welds including edge preparation of fusion faces shall be as per details shown on the drawings and shall be submitted in writing in accordance with IS:9595 for the approval of the Engineer before commencing fabrication. Any deviation from this procedure has to be approved by the Engineer. Preparation of edges shall, wherever practicable, be done by machine methods.

Machine flame cut edges shall be substantially as smooth and regular as those produced by edge planing and shall be left free of slag. Manual flame cutting shall be permitted by the Engineer only where machine cutting is not practicable.

Electrodes to be used for metal arc welding shall comply with relevant IS Specifications mentioned in IRC:24. Procedure test shall be carried out as per IS:8613 to find out suitable wire-flux combination for welded joint.

Assembly of parts for welding shall be in accordance with provisions of IS:9595.

Welded temporary attachment should be avoided as far as possible. If unavoidable, the method of making any temporary attachment shall be as approved by the Engineer. Any scars from temporary attachment shall be removed by cutting and chipping and surface shall be finished smooth by grinding to the satisfaction of the Engineer.

Welding shall not be carried out when the air temperature is less than 10°C, when the surfaces are wet, during periods of strong winds and in snowy weather, unless the work and the welding operators are adequately protected.

**1003.8.2** For welding of any particular type of joint, welders shall undergo the appropriate welders qualification test as prescribed in any of the relevant Indian Standards IS:817, IS:1966, IS:1393, IS:7307 (Part I), IS:7310 (Part I) and IS:7318 (Part I) to the satisfaction of the Engineer.

**1003.8.3** In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as to avoid distortion and minimize shrinkage stress.

All requirements regarding pre-heating of parent material and interpass temperature shall be in accordance with provisions of IS:9595.

**1003.8.4** Peening of weld shall be carried out wherever specified by the Engineer:

a) If specified, peening may be employed to be effective on each weld layer except first.

b) The peening should be carried out after weld has cooled by light blows from a power hammer using a round nosed tool. Care shall be taken to prevent scaling or flaking of weld and base metal from over peening.

**1003.8.5** Where the Engineer has specified that the butt welds are to be ground flush, the loss of parent metal shall not be greater than that allowed for minor surface defects. The ends of butt joints shall be welded so as to provide full throat thickness. This may be done by use of extension pieces, cross runs or other means approved by the Engineer. Extension pieces shall be removed after the joint has cooled and the ends of the weld shall be finished smooth and flush with the faces of the abutting parts.

The following joints and welds which do not perform well under cyclic loading are prohibited.

a) Butt joints not fully welded throughout their cross section

b) Groove welds made from one side only without any backing grip

c) Intermittent groove welds

d) Intermittent fillet welds

e) Bevel-grooves and J-grooves in butt joints for other than horizontal position

f) Plug and slot welds

**1003.8.6** The run-on and run-off plate extension shall be used for providing full throat thickness at the end of butt welded joints. These plates shall comply with the following requirements.

i) One pair of run-on and one pair of run-off plates prepared from same thickness and profile as the parent metal shall be attached to start and finish of all butt welds, preferably by clamps.

ii) When run-on and run-off plates are removed by flame cutting, they shall be cut at more than 3 mm away from the parent metal and the remaining metal of the plates shall be removed by grinding or by any other method approved by the Engineer.

**1003.8.7** *Welding of stud shear connectors*

The stud shear connectors shall be welded in accordance with the manufacturer's instructions including pre-heating.

The stud and the surface to which it is to be welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanised or cadmium plated prior to welding.

The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs.

The procedural trial for welding the stud shall be carried out when specified by the Engineer.

### 1003.9 Tolerances

Tolerances in dimensions of components of fabricated structural steel work shall be specified on the drawings and shall be subject to the approval of the Engineer before fabrication. Unless otherwise specified, all parts of an assembly shall fit together accurately within tolerances specified in **Table 1000.2**.

A machined bearing surface, where specified by the Engineer, shall be machined within a deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5 m.

**Table 1000.2 Fabrication Tolerances**

| | | |
|---|---|---|
| **A.** | **INDIVIDUAL COMPONENTS** | |
| 1) | Length | |
| a) | Member with both ends finished for contact bearing | ± 1 mm |
| b) | Individual components of members with end plate connection | 0 mm<br>- 2 mm |
| c) | Other members of length | |
| | i) Upto and including 12 m | ± 2 mm |
| | ii) Over 12 m | ± 3.5 mm |
| 2) | Width | |
| a) | Width of built-up girders | ± 3 mm |
| b) | Deviation in the width of members required to be inserted in other members | 0 mm<br>- 3 mm |
| 3) | Depth | |
| | Deviation in the depths of solid web and open web girders | + 3 mm<br>- 2 mm |
| 4) | Straightness | |

| | | |
|---|---|---|
| | Deviation from straightness of columns | L/3000 subject to maximum of 15 mm where L is length of member |
| | i) in elevation | + 5 mm<br>- 0 mm |
| | ii) In plan | L/1000 subject to a maximum of 10 mm |
| 5) | Deviation of centre line of web from centre line of flanges in built-up members at contact surface | 3 mm |
| 6) | Deviation from flatness of plate of webs of built-up members in a length equal to the depth of the members | 0.005d subject to a maximum of 2 mm where d is depth of member |
| 7) | Tilt of flange of plate girders | |
| a) | At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings | 0.005b subject to a maximum of 2 mm where b is width of the member |
| b) | at other places | 0.015b subject to a maximum of 4 mm where b is width of the member. |
| 8) | Deviation from squareness of flange to web of columns and box girders | L/1000, where L is nominal length of the diagonal |
| 9) | Deviation from squareness of fixed base plate (not machined) to axis of columns. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate | D/500, where D is the distance from the column axis to the point under consideration on the base plate |
| 10) | Deviation from squareness of machined ends to axes of columns | D/1000, where D is as defined in 9 above |
| 11) | Deviation from squareness of machined ends to axes of beams | D/1000, where D is as defined in 9 above |
| 12) | Ends of members abutting at joints through cleats or end plates, permissible deviation from squareness of ends | 1/600 of depth of member subject to a maximum of 1.5 mm |

## 1004 ERECTION

### 1004.1 General

These provisions shall apply to erection of steel bridge superstructures or steel main members of bridge superstructures, which span between supports.

If the substructure and the superstructure are built under separate contracts, the Employer will provide the substructure, constructed to correct lines, dimensions and elevations properly finished and will establish the lines and the elevation required for erection purposes.

The Contractor shall erect the structural steel, remove the temporary construction, and do all work required to complete the construction included in the contract in accordance with the drawings and the specifications and to the entire satisfaction of the Engineer.

### 1004.2 Organisation and Equipment

The Contractor shall submit erection plans prepared by the fabricator showing the method and procedure of erection, compatible with the details of fabrication.

A detailed scheme shall be prepared showing stagewise activities, with complete drawings and working instructions. This should be based on detailed stagewise calculations taking into account specifications and capacity of erection equipment machinery, tools and tackles to be used and temporary working loads as per codal provisions.

The scheme shall also take into account site conditions such as hydrology, rainfall, flood timings and intensity, soil and sub-soil conditions in the river bed and banks, maximum water depth, temperature and climatic conditions and available working space.

The scheme shall indicate precisely the type of temporary fasteners to be used as also the minimum percentage of permanent fasteners to be fitted during the stage erection. The working drawings should indicate clearly the temporary jigs, fixtures, clamps, spacer supports, etc.

Unless otherwise provided in the contract, the Contractor shall supply and erect all necessary falsework and staging and shall supply all labour, tools, erection plant and other materials necessary to carry out the work complete in all respects.

The Contractor shall supply all rivets, bolts, nuts, washers, etc. required to complete erection at site with an allowance for wastage of 12½ percent of the net number of field rivets, bolts, washers required, or a minimum of five number of each item.

Service bolts and nuts, washers and drifts for use in erection shall be supplied at 60 percent (45 percent bolts and 15 percent drifts) of the number of field rivets per span in each size (this includes wastage). A reduction in the number of service bolts, etc., may however, be specified by the Engineer if more than one span of each type is ordered.

Prior to actual commencement of erection, all equipment, machinery, tools, tackles, ropes, etc. need to be tested to ensure their efficient working. Frequent visual inspection of vulnerable areas is essential to detect displacements, distress, damages, etc.

Deflection and vibratory tests shall be conducted on supporting structures, launching truss and also the structure under erection. Any unusual deviation or looseness of fittings, are to be noted and reviewed.

For welded structures, welders' qualifications and skills are to be checked as per standard norms. Non-destructive tests of joints as per designer's directives are to be carried out.

Precision non-destructive testing instruments should be used for frequent checking of various important parameters of the structures and systematic records should be maintained.

Safety requirements should conform to IS:7205, IS:7273 and IS:7269 as applicable and all aspects of safety and speed of construction should be considered.

Erection work should start with complete resources mobilized as per latest approved drawings and after a thorough survey of foundations and other related structural work. For works of large magnitude, mechanization is to be adopted to the maximum extent possible.

The structure should be divided into erectable modules as per the scheme. The module should be pre-assembled in a suitable yard/platform and its matching with members of the adjacent module checked by trial assembly before erection.

The structure shall be set out to the required lines and levels. The steelwork should be erected, adjusted and completed in the required position to the specified lines and levels with sufficient drifts and bolts. Packing materials shall be available to maintain this condition. Quality surveillance checks need to be carried out frequently.

Before starting work, the Contractor shall obtain necessary approval of the Engineer for the methodology of erection and the number and character of tools and plant. The approval of the Engineer shall not relieve the Contractor of his responsibility for the safety of his methodology and equipment or from carrying out the work fully in accordance with the drawings and specifications.

During execution, the Contractor shall have a competent engineer or foreman in charge of the work, with adequate experience in steel erection who is acceptable to the Engineer.

### 1004.3 Handling and Storing of Materials

Suitable area for storage of structures and components shall be located near the site of work. The access road should be free from water logging during the working period and the storage area should be on firm, levelled ground.

The store should be provided with adequate handling equipment viz. mobile crane, gantries, derricks, chain pulley blocks, winch of capacity as required. Stacking area should be planned and have racks, stands sleepers, access tracks, etc., and proper lighting.

Storage should be planned to suit erection work sequence and avoid damage or distortion. Excessively rusted, bent or damaged steel shall be rejected. Methods of storage and handling steel, whether fabricated or not, shall be subject to the approval of the Engineer.

Fabricated materials are to be stored with erection marks visible. They should not come into contact with earth surface or water and should be accessible to handling equipment.

All materials, consumables, including raw steel or fabricated material shall be stored specification-wise and size-wise above the ground upon platforms, skids or other supports. They shall be kept free from dirt and other foreign matter and shall be protected as far as possible from corrosion and distortion. Electrodes shall be stored specification-wise and shall be kept in dry warm condition in properly designed racks. The bolts, nuts, washers and other fasteners shall be stored in gunny bags on racks above the ground with protective oil coating. Paint shall be stored under cover in air-tight containers. Small hand tools shall be kept in containers in covered stores.

IS:7293 and IS:7969 dealing with handling of materials and equipment for safe working should be followed. Safety nuts and bolts as directed are to be used while working. The Contractor shall be held responsible for loss or damage to any material paid for by the Employer while in his care or for any damage to such material resulting from his work.

### 1004.4 Formwork

The formwork shall be properly designed, substantially built and maintained for all anticipated loads. The Contractor, if required, shall submit plans for approval to the Engineer. Approval of the plans, however, shall not relieve the Contractor of his responsibility for adequacy and effective performance of the formwork.

### 1004.5 Straightening Bent Material

The straightening of plates, angles and other shapes shall be done by methods not likely to produce fracture or any injury. The metal shall not be heated unless permitted by the Engineer in special cases. The heating shall not be to a temperature higher than that producing a dark cherry red colour. This shall be followed by as slow cooling as possible. Following the straightening of a bend or buckle, the surface shall be carefully investigated for evidence of fracture. Sharp kinks and bends may lead to rejection of material.

### 1004.6 Assembling Steel

The parts shall be accurately assembled as shown on the drawings and match marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

Hammering which will injure or distort the members shall not be done. Bearing surface or surfaces to be in permanent contact shall be cleaned, before the members are assembled. The truss spans shall be erected on blocking, so placed as to give the proper camber. The blocking shall be left in place until the tendon chord splices are fully riveted and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung.

All joint surface for bolted connections including bolts, nuts, washers shall be free from scale, dirt, burrs, other foreign materials and defects that would prevent solid seating of parts. The slope of surface of bolted parts in contact with bolt head and nut shall not exceed 1 in 20, in a plane normal to bolt axis, in case it does, suitable tapered washer shall be used.

All fasteners shall have a washer under nut or bolt head whichever is turned in tightening.

Any connection to be riveted or bolted shall be secured in close contact with service bolts or with a sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Joints shall normally be made by filling not less than 50 percent of holes with service bolts and barrel drifts in the ratio 4:1. The service bolts are to be fully tightened as soon as the joint is assembled. Connections to be made by close tolerance or barrel bolts shall be completed as soon as practicable after assembly.

Any connection to be site welded shall be securely held in position by approved methods to ensure accurate alignment, camber and elevation before welding is commenced.

The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer. In such cases, the method of correction shall be approved by the Engineer and carried out in his presence.

### 1004.7 Field Inspection

### 1004.7.1 *General*

All materials, equipment and work of erection shall be subject to the inspection of the Engineer who shall be provided with all facilities required for this purpose, including labour and tools at all reasonable times. Any work found defective is liable to be rejected.

**1004.7.2** No protective treatment shall be applied to the work until the appropriate inspection and testing have been carried out. The stage inspection shall be carried out for all operations so as to ensure correctness of fabrication and good quality. Girder dimensions and camber shall not be finally checked until all welding and heating operations are completed and the member has cooled to a uniform temperature.

### 1004.7.3 *Testing of material*

Structural steel shall be tested for mechanical and chemical properties as per appropriate IS codes as may be applicable and shall conform to requirements specified in IS:226, IS:2062, IS:11587, IS:1977, IS:8500 and IS:961.

Rivets, bolts, nuts, washers, welding consumables, steel forging, casting and stainless steel shall be tested for mechanical and chemical properties in accordance with the appropriate IS Code.

Rolling and cutting tolerance shall be as per IS:1852. The thickness tolerance check measurements for plates and rolled sections shall be taken at not less than 15 mm from edge.

Check for laminations in plates shall be carried out by ultrasonic testing or any other specified method.

Steel work shall be inspected for surface defects and exposed edge laminations during fabrication and blast cleaning. Significant edge laminations found shall be reported to the Engineer for his decision.

Chipping, grinding, machining or ultrasonic testing shall be used to determine depth of imperfection.

### 1004.7.4 *Testing of connections*

Bolts and bolted connection joints with high strength friction grip bolts, shall be inspected and tested according to IS:4000.

Rivets and riveted connection shall be inspected and tested for compliance of codal requirements.

The firmness of joint shall be checked by 0.2 mm filler gauge, which shall not go inside under the rivet head by more than 3 mm. There shall not be any gap between members to be riveted.

Driven rivets shall be checked with rivet testing hammer. When struck sharply on the head with the hammer, the rivet shall be free from movement and vibration.

All loose rivets and rivets with cracks, badly formed or deficient heads or with heads which are eccentric with shanks, shall be cut out and replaced.

The alignment of plates at all bolted splice joints and welded butt joints shall be checked for compliance with codal requirements.

Testing of flame cut and sheared edges is to be done, where the hardness criteria given in the code are adopted. Hardness testing shall be carried out on six specimens.

### 1004.7.5 *Welding*

Welding procedure, welded connection and testing shall be in compliance with codal requirements.

All facilities necessary for stage inspection during welding and on completion shall be provided to the Engineer or his inspecting authority by fabricator.

Adequate means of identification either by identification mark or other record shall be provided to enable each weld to be traced to the welder(s) by whom its welding was carried out.

All metal arc welding shall be in compliance with provisions of IS:9595.

The method of inspection shall be in accordance with IS:822 and extent of inspection and testing shall be in accordance with the relevant standards or as agreed with the Engineer.

#### *1004.7.5.1 Procedure tests*

The destructive and non-destructive test of weld shall be carried out according to IS:7307 (Part I).

**Non-Destructive Testing of Welds**

One or more of the following methods may be applied for inspection or testing of weld:

i) **Visual Inspection:** All welds shall be visually inspected, to cover all defects of weld such as size, porosity, crack in the weld or in the HAZ (Heat Affected Zone) etc. Suitable magnifying glass may be used for visual inspection. A weld shall be acceptable by visual inspection if :

a) The weld has no cracks.

b) Thorough fusion exists between weld and base metal and between adjacent layers of weld metal.

c) Weld profiles are in accordance with relevant clauses of IS:9595 or as agreed with the Engineer.

d) The weld is of full cross section, except for the ends of intermittent fillet welds outside their effective length.

e) When weld is transverse to the primary stress, undercut shall not be more than 0.25 mm deep in the part that is undercut. When the weld is parallel to the primary stress, undercut shall not be more than 0.8 mm deep in the part that is undercut.

f) The fillet weld in any single continuous weld shall be permitted to under run the nominal fillet weld size specified by 1.6 mm without correction, provided that the undersized portion of the weld does not exceed 10 percent of the length of the weld. On the web-to-flange welds of girders, no under-run is permitted at the ends for a length equal to twice the width of the flange.

g) The piping porosity in fillet welds shall not exceed one in each 100 mm of weld length and the maximum diameter shall not exceed 2.4 mm, except for fillet welds connecting stiffeners to web, where the sum of diameters of piping porosity shall not exceed 9.5 mm in any 25 mm length of weld and shall not exceed 19 mm in any 300 mm length of weld.

h) The full penetration groove weld in butt joints transverse to the direction of computed tensile stress, shall have no piping porosity. For all other groove welds, the piping porosity shall not exceed one in 100 mm of length and the maximum diameter shall not exceed 2.4 mm.

ii) **Magnetic Particle and Radiographic Inspection :** Welds that are subject to radiographic or magnetic particle testing in addition to visual inspection, shall have no crack.

Magnetic particle test shall be carried out according to IS:5334 for detection of crack and other discontinuity in the weld.

Radiographic test shall be carried out for detection of internal flaws in the weld such as crack, piping porosity inclusion, lack of fusion, incomplete penetration, etc. This test may be carried out as per IS:1182 and IS:4853.

iii) **Ultrasonic Inspection :** Ultrasonic testing in addition to visual inspection shall be carried out for detection of internal flaws in the weld such as cracks, piping porosity inclusion, lack of fusion, incomplete penetration, etc. Acceptance criteria shall be as per IS:4260 or any other relevant IS Specification and as agreed to by the Engineer.

iv) **Liquid Penetration Inspection :** The liquid penetration test shall be carried out for detection of surface defect in the weld, as per IS:3658, in addition to visual inspection, non-destructive testing of the following welds shall be carried out using any of the methods described above, as may be agreed to by the Engineer.

a) All transverse butt welds in tension flanges

b) 10 percent of the length of longitudinal and transverse butt welds in tension flanges.

c) 5 percent of the length of longitudinal and transverse butt welds in compression flanges.

d) All transverse butt welds in webs adjacent to tension flanges as specified by the Engineer.

The particular length of welds in webs to be tested shall be agreed with the Engineer, in case (b) or (c).

Where specified by the Engineer, bearing stiffeners or bearing diaphragms adjacent to welds, flange plates adjacent to web/flange welds, plates at cruciform welds, plates in box girder construction adjacent to corner welds or other details shall be ultrasonically tested after fabrication.

Any lamination, lamellar tearing or other defect found shall be recorded and reported to the Engineer for his decision.

*1004.7.5.2 Testing of Welds for Cast Steel :* The testing of weld for cast steel shall be carried out as agreed to and directed by the Engineer.

*1004.7.5.3 Stud Shear Connectors :* Stud shear connectors shall be subjected to the following tests:

a) The fixing of studs after being welded in position shall be tested by striking the side of the head of the stud with a 2 kg hammer to the satisfaction of the Engineer.

b) The selected stud head shall not show displacement of more than 0.25 times the height of the stud, from its original position, if struck once with a 6 kg hammer. The stud weld shall not show any sign of a crack.

The studs whose welds have failed the tests given in (a) and (b) shall be replaced.

### **1004.7.6** *Inspection requirement*

The fabricated member/component made out of rolled and built-up section shall be checked for compliance of the tolerances given in **Table 1000.2**. Inspection of member/components for compliance with tolerances, and the check for deviations shall be made over the full length.

During checking, the inspection requirement shall be indicated in such a manner that local surface irregularities do not influence the results.

For plate, out-of-plane deviation shall be checked at right angle to the surface over the full area of plate.

The cross girder or cross frame deviation shall be checked over the middle third of its length between each pair of webs and at the end of member for cantilever.

The web of rolled beam or channel section shall be checked for out-of-plane deviation in a longitudinal direction over a length equal to the depth of the section.

During inspection, the component/member shall not have any load or external restraint.

**Inspection Stages :** The stages of inspection to be carried out for compliance of tolerances shall include but not be limited to the following :

a) For completed parts, component/members - on completion of fabrication and before any subsequent operation such as surface preparation, painting, transportation, erection.

b) For webs of plate and box girder, longitudinal compression flange stiffeners in box girders and orthotropic decks and all web stiffeners at site joints - on completion of site joint.

c) For cross girders and frames, cantilevers in orthotropic decks and other parts in which deviations have apparently increased - on completion of site assembly.

Where, on checking member/component for out-of-plane or out-of-straightness at right angles to the plate surface, and any other instances, the deviation exceeds the tolerance, the maximum deviation shall be measured and recorded. The record shall be submitted to the Engineer who will determine whether the component / member may be accepted without rectification, accepted with rectification or rejected.

## 1005 PAINTING

### 1005.1 General

Unless otherwise specified, all metal work shall be given approved shop coats as well as field coats of painting. The item of work shall include preparation of metal surfaces, application of protective covering and drying of the paint coatings along with all tools, scaffolding, labour and materials necessary.

Coatings shall be applied only to dry surfaces and the coated surfaces shall not be exposed to rain or frost before they are dry. The coatings shall be applied to all surfaces excluding shear connectors and inner surfaces of fully sealed hollow sections. While coating adjacent surfaces, care shall be taken to ensure that primer is not applied on the shear connectors.

#### 1005.1.1 *Types of paints*

i) Ordinary Paints

These include paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy, etc.

Ordinary painting can generally be sub-divided into two types:

a) Primary Coats :

This shall be applied immediately after the surface preparation and should have the properties of adhesion, corrosion inhibition and imperviousness to water and air.

b) Finishing Coats :

This shall be applied over the primary coat and should have the properties of durability, abrasion resistance, aesthetic appearance and smooth finish.

ii) Chemical Resistant Paints

The more highly corrosion resistant paints can be divided into two main groups :

a) One pack paints (ready for use)

b) Two pack paints (mixed before use)

The two pack paints shall be mixed together just before use since they remain workable thereafter only for a restricted period of time.

All paints shall conform to relevant IS Standards as appropriate.

**1005.1.2** Surfaces which are inaccessible for cleaning and painting after fabrication shall be painted as specified before being assembled for riveting.

All rivets, bolts, nuts, washers etc., are to be thoroughly cleaned and dipped into boiling linseed oil conforming to IS:77.

All machined surfaces are to be well coated with a mixture of white lead conforming to IS:34 and mutton tallow conforming to IS:887.

In site painting, the whole of the steel work shall be given the second cover coat after final passing and after touching up the primer and cover coats, if damaged in transit.

**1005.1.3** Quality of paint : Only paints which have been tested for the following qualities as per the specifications given in the relevant IS codes, should be used :

- Weight test (weight per 10 litre of paint thoroughly mixed)
- Drying time
- Flexibility and adhesion
- Consistency
- Dry thickness and rate of consumption

**1005.1.4** Unless otherwise specified, all painting and protective coating work shall be done in accordance with IS:1477 (Part I).

### 1005.2 Surface Preparation

Steel surface to be painted either at the fabricating shop or at the site of work shall be prepared in a thorough manner with a view to ensuring complete removal of mill scale by one of the following processes as agreed to between the fabricator and the Engineer :

a) Dry or wet grit/sand blasting

b) Pickling which should be restricted to single plates, bars and sections

c) Flame cleaning

Primary coat shall be applied as soon as practicable after cleaning and in case of flame cleaning, while the metal is still warm.

All slag from welds shall be removed before painting. Surfaces shall be maintained dry and free from dirt and oil. Work out of doors in frosty or humid weather shall be avoided.

### 1005.3 Coatings

Prime coat to be used shall conform to the specification of primers approved by the Engineer. Metal coatings shall be considered as prime coats. Primer shall be applied to the blast cleaned surface before any deterioration of the surface is visible. In any case, the surface shall receive one coat of primer within 4 hours of abrasive blast cleaning.

All coats shall be compatible with each other. When metal based coatings are used, the undercoat shall be compatible with the concerned metal base. The undercoat and finishing coat shall preferably be from the same manufacturer. Successive coats of paints shall be of different shades or colours and each shall be allowed to dry thoroughly before the next is applied. Particular care shall be taken with the priming and painting of edges, corners, welds and rivets. Typical guidelines for epoxy based paints and the conventional painting system for bridge girders as given below may be complied with :

a) **Epoxy Based Painting**

   i) Surface preparation : Remove oil/grease by use of petroleum hydrocarbon solution (IS:1745) and grit blasting to near white metal surface.

   ii) Paint system : 2 coats of epoxy zinc phosphate primer = 60

   micron : Total 5 coats = 200 micron

b) **Conventional Painting System for areas where corrosion is not severe**

   **Priming Coat :**

   One coat of ready mixed, red lead primer conforming to IS:102

   or

   One coat of ready mixed zinc chrome primer conforming to IS:104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS:2074.

or

Two coats of red oxide zinc chrome primer conforming to IS:2074.

**Finishing Coats :**

Two cover coats of red oxide paint conforming to IS:123 or any other approved paint shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

c) **Conventional Painting System for areas where corrosion is severe**

**Priming Coat :**

Two coats of ready mixed red lead primer conforming to IS:102

or

One coat of ready mixed zinc chrome primer conforming to IS:104 followed by one coat of ready mixed zinc chrome primer conforming to IS:2074.

**Finishing Coats :**

Two coats of aluminium paint conforming to IS:2339 shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

### 1005.4 Painting in the Shop

All fabricated steel shall be painted in the shop after inspection and acceptance with at least one priming coat, unless the exposed surfaces are subsequently to be cleaned at site or are metal coated. No primer shall be applied to galvanised surfaces.

Shop contact surfaces, if specifically required to be painted, shall be brought together while the paint is still wet.

Field contact surfaces and surfaces to be in contact with cement shall be painted with primer only. No paint shall be applied within 50 mm of design location of field welds. Paint shall be completely dry before loading and transporting of the fabricated steel work to site.

Surfaces not in contact but inaccessible after shop assembly shall receive the full specified protective treatment before assembly.

Where surfaces are to be welded, the steel shall not be painted or metal coated within a suitable distance from any edges to be welded if the specified paint or metal coating would be harmful to welders or is likely to impair the quality of site welds.

Exposed machined surfaces shall be adequately protected.

### 1005.5 Painting at Site

Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat.

Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets.

Specified protective treatment shall be completed after erection.

### 1005.6 Methods of Application

The methods of application of all paint coatings shall be in accordance with the manufacturer's written recommendation and shall be as approved by the Engineer. Spray painting may be permitted provided it will not cause inconvenience to the public and is appropriate to the type of structure being coated. Areas inaccessible for painting and areas shaded for spray application, shall be coated first by brushing.

Oil based red lead primers must be applied by brush only, taking care to work into all corners and crevices.

The primer, intermediate and finishing coats shall all be applied so as to provide smooth coatings of uniform thickness. Wrinkled or blistered coatings or coatings with pinholes, sags, lumps or other blemishes shall not be accepted. Where the Engineer so directs, the coating shall be removed by abrasive blast cleaning and replaced at the Contractor's cost.

### 1005.7 Protective Coatings in Different Environments

Since the severity of corrosion depends upon atmospheric conditions and these vary enormously, there is no single protective system or method of application that is suitable for every situation.

**Table 1000.3** gives guidelines for various types of coatings to be used in various environmental conditions. Approximate life to first maintenance is also indicated.

**Table 1000.3 Guidelines for Selection of Types of Protective Coatings**

| S.No. | Type of Coating | Exposure Condition |
|---|---|---|
| i) | Wire brush to remove all loose rust and scale; 2 coats drying oil type primer, and 1 under coat alkyd type paint; 1 finishing coat alkyd type. Total dry thickness = 150 μm | Moderate |
| ii) | Wire brush to remove all loose rust and scale; 2 coats drying oil type primer; 2 under coats micaceous iron oxide (MXO) pigmented phenolic modified drying oil. Total dry film thickness = 170 μm (life up to 5 years) | Polluted inland environment |

| | | |
|---|---|---|
| iii) | Blast clean the surface; 2 coats of quick drying primer; undercoat alkyd type paint; 1 finishing coat alkyd type. Total dry film thickness : 130 – 150 μm | Moderate |
| iv) | Blast clean the surface; 2 coats of drying type oil primer; 1 undercoat micaceous iron oxide pigmented drying oil type paint. Total dry film thickness : 165–190 μm | Polluted inland environments |
| v) | Blast clean the surface; 2 coats of metallic lead pigmented chlorinated rubber primer, 1 undercoat of high build chlorinated rubber primer, 1 undercoat of high build chlorinated rubber; 1 finishing coat of chlorinated rubber. Total dry film thickness : 200 μm | Severe coastal and non-coastal interior situations |
| vi) | Blast clean the surface; 350 – 450 μm thickness coal tar epoxy. | Severe |
| vii) | Pickle; hot dip galvanised (Zinc).<br>Total thickness : 85 μm<br>(life up to 15-20 years) | Moderate |
| viii) | Grit blast, hot dip galvanised. (Zinc).<br>Total thickness = 140 μm<br>(life more than 20 years) | Moderate |
| ix) | Grit blast; 1 coat of sprayed zinc/ aluminum followed by suitable sealer<br>Total thickness = 150 μm<br>(life up to 15-20 years) | Severe |

## 1006 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with relevant IS Specifications and necessary test certificates shall be furnished. Additional tests, if required, shall be got carried out by the Contractor at his own cost.

The fabrication, furnishing, erection and painting of structural steel work shall be in accordance with these Specifications and shall be checked and accepted by the Engineer.

## 1007 MEASUREMENTS FOR PAYMENT

This item shall be measured in tonnes based on the net weight of metal in the fabricated structure, computed on the basis of nominal weight of materials.

The weight of rolled and cast steel and cast iron shall be determined from the dimensions shown on the drawings on the following basis :

- Rolled or cast steel : 7.84 x $10^{-3}$ kg/cu.cm.
- Cast Iron : 7.21 x $10^{-3}$ kg/cu.cm.

Weight of structural sections shall be nominal weight.

Weight of castings shall be computed from the dimensions shown on the drawings with an addition of 5 percent for fillets and over-runs.

Weight of rivet heads shall be computed by taking the weight of 100 snap heads as given in **Table 1000.3**.

When specially agreed upon, allowance for snap heads may be taken as a flat 2.5 percent of the total weight.

**Table 1000.4 Weight of Rivet Heads**

| Dia of Rivet as Manufactured mm | Weight of 100 Snap Heads Kg |
|---|---|
| 12 | 1.3 |
| 14 | 2.1 |
| 16 | 3.4 |
| 18 | 4.45 |
| 20 | 6.1 |
| 22 | 8.1 |
| 24 | 10.5 |
| 27 | 15.0 |
| 30 | 20.5 |
| 33 | 27.2 |

The Contractor shall supply detailed calculation sheets for the weight of the metal in the fabricated structure.

No additions shall be made for the weight of protective coatings, weld fillets, bolts, nuts and washers.

Where computed weight forms the basis for payment, the weight shall be calculated for exact cut sizes of members used in the structure, deductions being made for all cuts, except for rivet holes. Additions shall be made for the rivet heads as mentioned above.

When specially agreed upon, the basis for payment may be the bridge weight complete, according to specifications included in special provision of the Contract.

## 1008 RATE

The contract unit rate for the completed structural steel work shall include the cost of all materials, labour, tools, plant and equipment required for fabrication, connections, oiling, painting, temporary erection, inspection, tests and complete final erection as shown on the drawings or as directed by the Engineer and in accordance with these Specifications.

## 1100

# PIPE CULVERTS AND VENTED CAUSEWAYS

## 1101 PIPE CULVERTS

### 1101.1 Scope

This work shall consist of furnishing and installing reinforced cement concrete pipes of the type, diameter and length required at the locations shown on the drawings or as directed by the Engineer and in accordance with the requirements of these Specifications.

### 1101.2 General

Humps or dips in the vertical profile of the road at the location of pipe culverts shall be avoided.

Pipes of less than 500 mm internal diameter used for irrigation water crossings/channels shall be considered as buried conduits and not culverts.

It is not economical to provide high headwalls to retain deep overfill. In such cases, the length of the pipe culvert shall be suitably increased and side slope flattened in full multiple of available pipe length (generally 2.5 m or 3 m) so that the road embankment with its natural slopes, is accommodated without high retaining headwalls and cutting of pipes is avoided.

The wearing surface of the road shall generally be carried over the pipe culvert unless specified otherwise on the drawings or directed by the Engineer.

Fill above the top of pipe up to the finished road level shall not be less than 600 mm.

### 1101.3 Materials

Reinforced concrete pipes for culverts shall be of NP-3 or NP-4 type conforming to the requirements of IS:458 as specified in the drawings. The internal diameter of reinforced concrete pipes shall be not less than 900 mm except in exceptional situations where it may be 600 mm or 750 mm.

Buried conduits used for irrigation purposes shall consist of reinforced concrete pipes of the size (generally 300 to 500 mm internal diameter) and type (either NP-3 or NP-4) as approved by the concerned department and as specified on the drawings.

All materials used in the work shall conform to the requirements of Section 2000 of these Specifications.

Each consignment of cement concrete pipes shall be inspected, tested, if necessary, and approved by the Engineer either at the place of manufacture or at the site before their incorporation in the works.

### 1101.4 Excavation for Pipe

The foundation bed of pipe culverts shall be excavated true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankment, taken down to levels as shown on the drawings.

In case of embankments of heights of fill more than 3 m above the bed level or three times the external diameter of the pipe, the embankment shall first be constructed to the level above the top of the pipe equal to the external diameter of the pipe and the width on either side of the pipe shall be not less than five times the diameter of the pipe. After the construction of embankment, a trench shall be excavated and the pipe shall be laid.

The pipe shall be placed where the ground for the foundation is reasonably firm. If spongy, soft or other unstable material is met with at the location of the pipe culvert; such unsuitable material shall be removed to such depth, width and length as directed by the Engineer. The excavation shall then be the backfilled with approved granular material which shall be properly shaped and thoroughly compacted upto the specified level.

The width of trench in the embankment on either side of the pipe shall be one-fourth of the diameter of the pipe subject to minimum of 150 mm and shall not be more than one third diameter of the pipe. The sides of the trench shall be as nearly vertical as possible.

Where rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock/ boulders in this area be removed and the space filled with approved earth, free from stones or fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Trenches shall be kept free from water until the pipes are installed and the joints have hardened.

### 1101.5 Bedding for Pipe

The bedding surface shall provide a firm foundation of uniform density throughout the length of the culvert and shall conform to the specified levels and grade. Bedding shall be of either of the following two types as specified on the drawings :

#### i) Type A (Concrete Cradle) bedding

Type A (Concrete Cradle) bedding shall be provided where height of fill above the pipe is more than 4 metres.

When indicated on the drawings or directed by the Engineer, the pipe shall be bedded in a cradle constructed of concrete having a mix not leaner than M15 or as specified on the drawings, conforming to Section 800 of these Specifications. The shape and dimensions of the cradle shall be as indicated on the drawings. The pipes shall be laid in accordance with the requirements of IS:783 on the concrete bedding before the concrete has set.

#### ii) Type B (First Class) bedding

Type B bedding shall be adopted where height of fill above the pipe is between 0.6 m and 4 m. Under type B bedding, the pipe shall be evenly bedded on a continuous layer of well compacted sand, moorum or approved granular material, shaped concentrically to fit the lower part of the pipe exterior for minimum 10 percent of its overall height or as otherwise shown on the drawings. The bedding material shall be well graded sand or other granular material passing 5.6 mm sieve suitably compacted/rammed. The compacted thickness of the bedding layer shall not be less than 75 mm or as specified on the drawings.

In case of expansive soils, like black cotton soil, which have very low bearing capacity, a layer of sand/moorum or non-expansive material shall be provided under the bedding. The thickness of the sand layer bedding shall be as specified on the drawings or as directed by the Engineer subject to the minimum thickness of 450 mm.

### 1101.6 Laying of Pipe

No pipe shall be laid in position until the foundation has been approved by the Engineer.

Where two or more pipes are to be laid adjacent of each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

If the pipes are laid in two layers, the minimum horizontal and diagonal distance between pipes shall be same as specified above and the centres of pipes shall form vertices of equilateral triangles.

The pipes shall be laid as per IS:783.

The arrangement for lifting, loading and unloading concrete pipes from factory/yard and at site shall be such that the pipes do not suffer any undue structural strain or any damage due to fall or impact.

In manual unloading of pipes from the trucks, pipes shall be rolled down on a pair of skids hooked on to the trucks, and the movement shall be controlled with a rope passing round the pipes, back to a rail or station, etc. The pipes shall be placed as near to the edge of the trench as possible and as safety permits to avoid possible damage during re-transportation.

The arrangement for lowering the pipe in the bed shall be got approved by the Engineer. It may either be with tripod pulley arrangement or simply by manual labour with the help of ropes or by chain blocks, etc. in a manner that the pipe is placed in the proper position without damage. Hooks shall not be used in the ends of the pipe to lift or lower down as this procedure is likely to damage joint surfaces.

The longitudinal slope of the pipe shall not be flatter than bed slope subject to minimum of 1 in 1000 in plains. In case of culverts in hilly areas, the longitudinal slope of the pipe shall be according to bed slope but not steeper than 1 in 30 unless otherwise specified on the drawings or directed by the Engineer.

The laying of pipes on the prepared foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. The invert of the pipe shall be minimum 150 mm below the average bed level. In case of use of pipes with bell-mouth, the belled end shall face upstream. The pipes shall be fitted and matched so that when laid in work, they form a culvert with a smooth uniform invert.

Any pipe found defective or damaged during laying shall not be used in the works and shall be removed by the Contractor at his own cost.

### 1101.7 Jointing

The pipes shall be jointed either by collar joints or by flush joint. The width of the collars shall be 150 to 200 mm. The collars shall be of reinforced cement concrete of the same strength as that of the pipes to be jointed. Caulking space shall be between 13 mm and 20 mm according to the diameter of the pipes. The collar shall be so placed that its centre coincides with the joints and even annular space is left between the collar and the pipe. Caulking material shall be slightly wet mix of cement and sand in the ratio of 1:2 rammed with caulking irons.

Flush joint shall be either internal flush joint or external flush joint. The ends of the pipes shall be specially shaped to form a self centering joint with a jointing space 13 mm wide. The jointing space shall be filled with cement mortar (1 cement to 2 sand), mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed.

For jointing pipe lines, the recess at the end of the pipe shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The rings shall be thoroughly compressed by a suitable method.

All joints shall be made with care so that interior surface in smooth and consistent with the interior surface of the pipes. After finishing, the joint shall be kept covered and damp for at least four days.

### 1101.8 Backfilling

Trenches shall be backfilled immediately after the pipes have been laid and the jointing material has hardened. The backfill soil shall be clean, free from boulders, large roots, clay lumps retained on 75 mm sieve, stones retained on 26.5 mm sieve and excessive amounts of sods or other vegetable matter and shall be approved by the Engineer.

Backfilling upto 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the haunches of the pipe using light mechanical tamping equipment.

Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur. The earthwork between the pipes shall be compacted thoroughly by hand compacting tools. Normally, granular material shall be used for the purpose. Care shall be exercised during compaction to prevent damage to pipes.

When it is not possible to provide the minimum specified cushion over the pipe, the pipe shall be encased in M10 concrete with cover of minimum 100 mm or as directed by the Engineer. The minimum cushion shall be measured at the edge of the roadway.

### 1101.9 Headwalls and Other Ancillary Works

Headwalls, wings walls, aprons and other connected works shall be constructed in accordance with the details shown on the drawings or as directed by the Engineer.

Brick masonry work in the pipe culvert shall conform to Section 600 of these Specifications.

Stone masonry work in the pipe culvert shall conform to Section 700 of these Specifications.

Concrete work in the pipe culvert shall conform to Section 800 of these Specifications.

Steel reinforcement work in the pipe culvert shall conform to Section 1000 of these Specifications.

Apron, pitching of slopes, flooring and curtain/cut off walls shall conform to Section 1300 of these Specifications.

### 1101.10 Opening to Traffic

No traffic shall be permitted to move over the pipe unless height of earth filling above the top of the pipe is at least 600 mm or as specified on the drawings.

### 1101.11 Measurements for Payment

RCC Pipes shall be measured along their centre between the inlet and outlet ends in linear metres.

Selected granular material and cement concrete for pipe bedding shall be measured as laid in cubic metres.

Ancillary works, like headwalls, etc. shall be measured as provided for under the respective Sections of these Specifications.

### 1101.12 Rate

The contract unit rate for the pipe shall include the cost of pipe including loading, unloading, hauling, handling, storing, laying in position and jointing complete and all incidental costs to complete the work in accordance with these Specifications.

Excavation, bedding, backfilling, concrete and masonry shall be paid for separately, as provided under the respective Sections.

## 1102 VENTED PIPE CAUSEWAY

### 1102.1 Scope

This work shall consist of furnishing and providing vented causeway including furnishing and installing reinforced cement concrete pipes of the type, diameter and length required at the locations shown on the drawings or as ordered by the Engineer and in accordance with the requirements of this Section.

### 1102.2 General

For design of vented pipe causeway, guidelines given in IRC:SP:82 or prevailing practice in the State may be followed.

### 1102.3 Materials

Material for construction of various components of vented pipe causeway shall conform to Section 2000 of these Specifications.

### 1102.4 Excavation for Pipe

The excavation for pipe causeway shall be in accordance with the requirements of Clause 1104 of these Specifications.

### 1102.5 Bedding for Pipe

The bedding for pipes shall be in accordance with the requirements of Clause 1101.5.

### 1102.6 Laying of Pipes

The laying of pipes shall be in accordance with the requirements of Clause 1101.6.

### 1102.7 Jointing of Pipes

The jointing of pipes shall be in accordance with requirements of Clause 1101.7.

### 1102.8 Back-Fillings

The back-filling shall be in accordance with the requirements of Clause 1101.8.

### 1102.9 Head Walls and Other Ancillary Works

**1102.9.1** The head walls shall be constructed true to lines and grades shown on the drawings or as directed by the Engineer.

**1102.9.2** *Excavation*

Excavation for foundation of bed of head walls shall be in accordance with the requirements of Section 300 of these Specifications.

**1102.9.3** *Foundation concrete for head-walls*

Foundation concrete for head-walls shall be in accordance with the requirements of Section 800 of these Specifications.

Laying of foundation concrete shall be in accordance with the requirements of Section 1200 of these Specifications.

## 1102.10 Pavement Construction

### 1102.10.1 *Preparation of sub-grade*

The preparation of sub-grade for laying pavement courses shall conform to the requirements of Section 300 of these Specifications.

### 1102.10.2 *Sub-base and base*

The sub-base and base shall conform to the requirements of Section 400 of these Specifications.

### 1102.10.3 *Cement concrete slab*

The minimum thickness of plain cement concrete slab shall be 200 mm and minimum grade of concrete shall be M30 or as specified in the drawings.

The sub base below cement concrete pavement shall conform to the requirements of Section 1500 of these Specifications.

The pavement shall be provided with proper cross slope of 2.5 percent, sloping down towards downstream side.

### 1102.10.4 *Construction joints*

Construction joint in CC pavements shall be spaced 4-6 m apart. The joints shall be sealed with polysulphide as per manufacturer's specifications.

## 1102.11 Guide Posts/Stones

The guide posts/stones shall be of reinforced cement concrete of M25 grade or as specified on the drawings or as directed by the Engineer. Stones can be used wherever available in place of RCC. The size of stone shall be 225 mm x 225 mm x 300 mm (above road level) and spaced at 1500 mm, centre to centre.

The guide posts of RCC shall be 250 mm diameter and of height as specified on the drawings and embedded full depth in concrete pavement or as indicated on the drawings.

The RCC post/stone shall be painted with alternate black and white bends with ordinary paint conforming to IS:164 or as directed by the Engineer.

## 1102.12 Apron

The work of apron shall conform to the requirements of Section 1300 of these Specifications.

## 1102.13 Pitching of Slope

The work shall be carried out in accordance with the requirements of Section 1300 of these Specifications.

### 1102.14 Opening to Traffic

Traffic shall be permitted on the causeway only after the concrete slab has been laid and cured for 28 days.

### 1102.15 Measurements for Payment

Providing, furnishing and laying of pipes shall be measured in accordance with Clause 1101.11 of these Specifications.

Earthwork in excavation, concrete footing, brick masonry, stone masonry, sub-base, base, concrete pavement, apron, pitching and guard posts shall be measured in accordance with relevant sections of these Specifications.

### 1102.16 Rate

The contract unit rate for the pipe shall include the cost of pipe including loading, unloading, hauling, handling, storing, laying in position and jointing complete and all incidental costs to complete the work in accordance with these Specifications.

Excavation, bedding, backfilling, concrete and masonry shall be paid for separately, as provided under the respective Sections.

Cement Concrete for pavement shall be paid as per Section 1500 of these Specifications.

# 1200

# FOUNDATION AND SUBSTRUCTURE FOR STRUCTURES

## 1201 GENERAL

For bridges having overall length of 30 m or more, a method statement indicating the following shall be submitted by the Contractor for approval of the Engineer, well in advance of the commencement of construction of foundation and substructure:

i) Sources of materials
ii) Design, erection and removal of formwork
iii) Production, transportation, laying and curing of concrete
iv) Personnel employed for execution and supervision
v) Tests and sampling procedures
vi) Equipment details
vii) Quality Management System to be adopted including Quality Manual
viii) Any other relevant information

Details of necessary arrangements for execution under water wherever necessary, shall be included in the method statement.

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark so that the foundations are located correctly and in accordance with the drawings.

## 1202 MATERIALS

Materials shall conform to Section 2000 of these Specifications.

## 1203 OPEN FOUNDATIONS

### 1203.1 Description

The work shall cover furnishing and providing plain or reinforced concrete foundation placed in open excavation, in accordance with the drawings and these Specifications or as directed by the Engineer.

### 1203.2 Workmanship

### 1203.2.1 *Preparation of foundations*

Excavation for laying the foundation shall be carried out in accordance with Section 300 of these Specifications. The last 300 mm of excavation shall be done just before laying of lean concrete below foundation. Excavation shall be made only to the exact depth as shown on the drawing. In the event of excavation having been made deeper than that shown on the drawing or as directed by the Engineer, the extra depth shall be made up with M10 concrete in case of foundation resting on soil and with concrete of the same grade as that of the foundation, in case of foundation resting on rock. This shall be done at the cost of the Contractor and shall be considered as incidental to the work.

Open foundations shall be constructed in dry conditions and the Contractor shall provide for adequate dewatering arrangements, wherever required, to the satisfaction of the Engineer.

Where light blasting is required for excavation in rock or other hard strata, the same shall be carried out in accordance with these Specifications. Where blasting is likely to endanger adjacent foundations or other structures, controlled blasting with all necessary precautions shall be resorted to.

### 1203.2.2 *Setting out*

The plan dimensions of the foundation shall be set out at the bottom of foundation trench and checked with respect to original reference line and axis. It shall be ensured that at no point the bearing surface is higher than the founding level shown on the drawing or as directed by the Engineer.

### 1203.2.3 Construction

i) Excavation for open foundations shall be carried out in accordance with dimensions of structure with 300 mm extra on all sides. For guidance regarding safety precautions to be taken, IS:3764 may be referred.

ii) For foundation resting on soil, a layer of M10 concrete of minimum thickness 100 mm shall be provided above the natural ground to provide an even surface to support the foundation concrete. Before laying of lean concrete layer, the earth surface shall be cleaned of all loose material and wetted. Care shall be taken to avoid muddy surface. If any part of the surface has become muddy due to over-wetting, the same shall be removed. If required, the M10 concrete may be laid to a thickness of more than 100 mm, as per the direction of the Engineer. No construction joint shall be provided in the lean concrete. For foundations resting on rock, the rock surface shall be cleaned of any loose material and then levelled with a layer of concrete of the same grade as that of the foundation, so as to provide an even surface.

iii) No point of the surface of the lean concrete, in the case of foundation on soil or the surface of hard rock, in the case of foundation on hard rock, shall be higher than the founding level shown on the drawing or as directed by the Engineer. Levels of the surface shall be taken at intervals of not more than 3 metres centre-to-centre in each direction, subject to a minimum of nine levels on the surface.

iv) No formwork is necessary for the lean concrete layer. Side formwork shall be used for foundation concrete work. When concrete is laid in slope without top formwork, the slump of the concrete shall be carefully maintained to ensure that compaction is possible without slippage of freshly placed concrete down the slope. In certain cases it may be necessary to build the top formwork progressively as the concreting proceeds up the slope. Reinforcement shall be laid as shown on the drawing.

v) Before laying foundation concrete, the lean concrete or hard rock surface shall be cleaned of all loose material and lightly moistened.

Foundation concrete of required dimensions and shape shall be laid continuously up to the location of construction joint shown on the drawing or as directed by the Engineer.

vi) The concrete surface shall be finished smooth with a trowel. The location of construction joint and its treatment shall be done as per requirements of Section 800 of these Specifications. Formwork shall not be removed earlier than 24 hours after placing of concrete. Where formwork has been provided for top surface, the same shall be removed as soon as concrete has hardened. Curing of concrete shall be carried out by wetting of formwork before removal. After its removal, curing shall be done by laying not less than 100 mm thickness of loose moistened sand free from clods or gravel, over the concrete. The sand shall be kept continuously moist for a period of 7 days. Before backfilling is commenced, the loose sand shall be removed and disposed of as directed by the Engineer.

vii) Normally, open foundations shall be laid dry. Where dewatering is necessary for laying of concrete, it shall be carried out adopting any one of the following methods or any other method, approved by the Engineer:

a) A pit or trench of suitable size, deeper than the founding level as necessary, is dug beyond the foundation excavation so that the water flows into it and the excavated surface at founding level is fully drained.

b) Water table is depressed by well point system or other methods.

c) Steel/concrete caissons or sheet piling are used for creating an enclosure for the foundations, which can subsequently be dewatered.

No pumping of water shall be permitted from the time of placing of concrete up to 24 hours after placement.

viii) In situations where foundations cannot be laid dry or where percolation is too heavy to keep foundation strata dry, concrete may be laid under water only by tremie. In case of flowing water or artesian spring, the flow shall be stopped or reduced to the feasible extent at the time of placing the concrete.

ix) Where blasting is required, it shall be carried out in accordance with Section 300 of these Specifications, observing all precautions indicated therein. Where blasting is likely to endanger adjoining foundations or other structures, necessary precautions such as controlled blasting, providing rubber mat cover to prevent flying of debris etc., shall be taken to prevent any damage.

x) All spaces excavated and not occupied by the foundations or other permanent works shall be refilled with earth up to surface of surrounding ground with sufficient allowance for settlement. All backfill shall be thoroughly compacted and in general, its top surface shall be neatly graded.

xi) In case of excavation in rock, the annular space around the footing shall be filled with M15 concrete up to the level of top of rock. Filling with M15 concrete shall also be carried out for excavations having depth up to 1.5 m in ordinary rock or 0.6 m in hard rock. In case, the excavations are even deeper so as to require further filling up to the level of top of rock, the same shall be done by boulders grouted with cement.

xii) Protective works, where provided shall be completed before the onset of floods so as to avoid the risk of the foundation getting undermined.

### 1203.3 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the criteria prescribed in Section 2000.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

### 1203.4 Tolerances

| | | | |
|---|---|---|---|
| i) | Variation in dimensions | : | +50 mm, -10 mm |
| ii) | Misplacement from specified position in plan | : | 15 mm |
| iii) | Surface unevenness measured with 3 m straight edge | : | 5 mm |
| iv) | Variation of levels at the top | : | ± 25 mm |

### 1203.5 Measurement for Payment

Excavation in foundation shall be measured in cubic metres in accordance with Section 300 of these Specifications, based on the quantity ordered or as shown on the drawing.

Lean concrete shall be measured in cubic metres in accordance with Section 800 of these Specifications, based on the quantity ordered or as shown on the drawing.

Concrete in foundation shall be measured in cubic metres in accordance with Section 800 of these Specifications, based on the quantity ordered or as shown on the drawing.

Reinforcement steel shall be measured in tonnes in accordance with Section 1000 of these Specifications, based on the quantity ordered or as shown on the drawing.

### 1203.6 Rate

The contract unit rates for excavation in foundation, lean concrete, including dewatering and blasting where required, concrete in foundation and reinforcement steel shall include all works as given in respective Sections of these Specifications and cover all incidental items for furnishing and providing open foundation as mentioned in this Section and as shown on the drawings.

# 1204 PILE FOUNDATIONS

## 1204.1 General

This work shall consist of construction of all types of piles for structures in accordance with the details shown on the drawings and conforming to the requirements of these Specifications or as directed by the Engineer.

The construction of pile foundations requires a careful choice of the piling system depending on subsoil conditions and loading characteristics and type of structure. The permissible limits of total and differential settlements, unsupported length of pile under scour, impact/ entanglement of floating bodies and any other special requirements of project, are also equally important criteria for selection of the piling system. The method of installing the piles, including details of the equipment shall be submitted by the Contractor and got approved from the Engineer before commencement of work.

The work shall be carried out as per IS:2911 except as modified herein.

## 1204.2 Subsurface Investigations

The complete subsurface investigations of strata in which pile foundations are proposed shall be carried out in advance along with in-situ pile tests.

Borings should be carried up to sufficient depths so as to ascertain the nature of strata around the pile shaft and below the pile tip. Depth of boring shall not be less than:

i) 1.5 times estimated length of pile in soil or 15 m below the proposed founding level

ii) 15 times diameter of pile in ordinary/jointed rock but minimum 15 m in such rock

iii) 4 times diameter of pile in hard rock but minimum 3 m in such rock

The subsurface investigations shall adequately define stratification of substrata including the nature and type of strata, their variation, extent and specific properties. The investigations shall be adequate for the purpose of selection of appropriate piling system and for estimating design capacities for different diameters and length of piles.

Pressure meter tests may be used in the case of rock, ground or soil for direct evaluation of strength and compressibility characteristics. Though these tests are of specialized nature, they are more appropriate for difficult/uncertain substrata and especially for important projects.

For piles socketed into rock, it is necessary to determine the uni-axial compressive strength of the rock and its quality.

The investigations shall also include location of ground water table and other parameters including results of chemical tests showing sulphate and chloride content and any other deleterious chemical content in soil and/or ground water, likely to affect durability.

### 1204.3 Type of Piles

Piles may be of reinforced concrete, prestressed concrete, steel or timber and circular, square, hexagonal, octagonal, "H" or "I" Section in shape. They may be of solid or hollow sections or steel cases filled with concrete. Timber piles may be used for temporary bridges. Cast in-situ concrete piles may be driven cast in-situ or bored cast in-situ. Similarly, precast concrete piles also may be driven precast or bored precast. In bored precast piles, precast piles are lowered into pre-formed bores and annular space grouted.

Minimum diameter of concrete pile shall be 1 m for river/marine bridges. For bridges beyond the water zone and bridges on land, the minimum diameter may be 750 mm.

### 1204.4 Materials

The basic materials shall conform to Section 2000 of these Specifications. The specifications for structural concrete, steel reinforcement, and structural steel to be used in pile foundations shall conform to Sections 800 and 1000 of these Specifications.

### 1204.5 Concrete in Piles

For both precast and cast in in-situ piles, the grade of concrete, minimum cement content, water cement ratio and slump at the time of placement shall be as per **Table 1200.1** :

**Table 1200.1 Requirements for Concrete in Piles**

| | **Cast in-situ concrete by Tremie** | **Precast Concrete** |
|---|---|---|
| Grade of concrete | M 35 | M 35 |
| Minimum cement content | 400 kg/m$^3$ | 400 kg/m$^3$ |
| Minimum water cement ratio | 0.40 | 0.40 |
| Slump as measured at the time of placement | 150-200 mm | 50-75 mm |

The terms 'minimum cement content' and 'minimum water cement' ratio mentioned in **Table 1200.1**, are to be based on total cementitious material (inclusive of all mineral admixtures called additives).

High alumina cements (i.e. quick setting cement) shall not be used in marine conditions. When both chlorides and sulphates are present, in soil or ground water, sulphate resistant cement shall not be used. For improving resistance against the penetration of chlorides and sulphates from surrounding soils or water, mineral admixtures such as fly ash, silica fumes, GGBS conforming to respective BIS / International Standards and as per IRC:112, may be used.

### 1204.6 Test Piles

Test piles which are shown on the drawings or specified in the contract or installed by the Contractor on his own to determine the length of piles to be furnished, shall conform to the requirements for piling as indicated in these Specifications. Test piles which are used to arrive at the load carrying capacity shall not be incorporated in the structure.

All test piles shall be installed with the same type of equipment that is proposed to be used for piling in the actual structure.

Test piles which are not to be incorporated in the completed structure shall be removed to at least 600 mm below the proposed soffit level of pile cap and the remaining hole so formed shall be backfilled with earth or other suitable material.

The piles shall be load tested in accordance with provisions laid down in this Section.

### 1204.7 Cast In-Situ Concrete Piles

#### 1204.7.1 *General*

Cast in-situ concrete piles may be either installed by drilling a bore into the ground and removing the material or by driving a metal casing with a shoe at the tip and displacing the material laterally. The two types of piles are termed as "bored piles" and "driven piles" respectively. Cast in-situ concrete piles may be cast in metal shells which may remain permanently in place. However, other types of reinforced concrete cast in-situ piles, cased or uncased, may be used if in the opinion of the Engineer, the soil conditions permit their use and if their design and the methods of placing are satisfactory.

Any liner or borehole which is improperly located or shows partial collapses that would affect the load carrying capacity of the pile, shall be rejected or repaired as directed by the Engineer at the cost of the Contractor.

Boring shall be carried out using rotary equipment. Percussion type of equipment shall be used only if approved by the Engineer.

The diameter of the finished pile shall not be less than that specified. A continuous record shall be kept by the Engineer as to the volume of concrete placed in relation to the length of pile that is cast.

Defective piles shall be removed or left in place as judged convenient without affecting the performance of adjacent piles or pile cap. Additional piles shall be provided to replace the defective piles.

#### 1204.7.2 *Concreting*

Wherever practicable, concrete should be placed in a clean dry hole. Prior to the placing of the reinforcement cage, the pile shaft shall be cleaned of all loose materials. Before concreting of the pile is commenced, it is essential to ensure that no debris remains at the bottom of the shaft, as inadequate cleaning of the base can lead to formation of a soft base or soft toe which may result in reduction of load bearing capacity of the pile.

Reinforcement for the pile as shown on the drawing shall be tied in place to form a cage which is lowered into the pile shaft. Suitable spacers shall be provided to maintain the required cover to reinforcing steel. Reinforcements at the bottom should not be provided with L-bends as these may interfere with cleaning of the pile base.

Where concrete is placed in dry and a casing is present, the top 3 m of the pile shall be compacted using internal vibrators.

Where the casing is withdrawn from cohesive soils for the formation of cast in-situ pile, the concreting should be done with necessary precautions to minimize the softening of the soil by excess water. Where mud flow conditions exist, the casing of cast in-situ piles shall not be allowed to be withdrawn.

Care shall be taken during concreting to prevent the segregation of the ingredients. The displacement or distortion of reinforcement during concreting and while extracting the casing, shall be avoided.

If the concrete is placed inside precast concrete tubes or consists of precast sections, these shall be free from cracks or other damage before being installed.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silty clays and other soils which have the tendency to squeeze into the newly deposited concrete and cause necking. Sufficient head of green concrete shall be maintained to prevent inflow of soil or water into the concrete.

The placing of concrete shall be a continuous process from the toe level to the top of the pile. To ensure compaction by hydraulic static heads, rate of placing concrete in the pile shaft shall not be less than 6 m (length of pile) per hour.

### **1204.7.3** *Casing*

When concreting is carried out for a pile, a temporary casing should be installed to sufficient depth so as to ensure that fragments of soil from the sides of the hole do not drop into the concrete as it is placed. When the bore hole is stabilized using drilling mud, the temporary casing is not required except near the top.

The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion while driving or when adjacent casings are driven.

Cast in-situ concrete driven piles shall be installed using a properly designed detachable shoe at the bottom of the casing.

Bored cast in-situ piles in soils which are stable, may often be installed with only a small casing length at the top. A minimum of 2 m length of top of bore shall invariably be provided with casing to ensure against loose soil falling into the bore. In cases in which the side soil can fall into the hole, it is necessary to stabilize the side of the bore hole with drilling mud, or a suitable steel casing. Permanent steel liner shall be provided at least up to maximum scour level. The minimum thickness of steel liner shall be 6 mm.

Permanent steel liner shall be provided for the full depth of the pile in the following situations where:

i) The surrounding soil is marine clay

ii) Soft soil is present

iii) Surrounding soil has sulphate content equal to or more than 1 percent

iv) Surrounding water has sulphate content equal to or more than 2500 ppm

v) Leakage of sewage is expected

For bored cast in-situ piles, casing/liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the depth shown on the drawing or as approved by the Engineer. Materials inside the casing shall be removed progressively by air lift, grab or percussion equipment or other approved means.

Where bored cast in-situ piles are used in soils liable to flow, the bottom of the casing shall be kept sufficiently in advance of the boring tool to prevent the entry of soil into the casing, leading to formation of cavities and settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level for the same reasons. The joints of the casing shall be made as leak-tight as possible to minimize inflow of water or leakage of slurry during concreting.

The diameter of the boreholes shall not be more than the inside diameter of the liner when the liners are installed before boring. When the liners are installed after boring, the diameter of the boreholes shall not be more than the outside diameter of liner + 2 mm, unless otherwise approved by the Engineer.

### **1204.7.4** *Use of tremie*

The concrete should invariably be poured through a tremie with a funnel, so that the concrete can be properly deposited in the hole without segregation. For concreting done by tremie, the following requirements which are particularly applicable shall be ensured:

i) The hopper and tremie should be a leak proof system.

ii) Diameter of tremie shall be not less than 200 mm for use with 20 mm diameter down aggregate.

iii) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it or with a steel plate with adequate charge to prevent mixing of concrete and water. However, the plug should not be left in the concrete as a lump.

iv) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal of the pipe. The tremie should be always full of concrete.

v) The pile should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile, to prevent laitance from being entrapped within the pile.

vi) All tremie tubes shall be thoroughly cleaned after use.

vii) For concrete placed through tremie, there is no need to add 10 percent extra cement.

viii) Concreting of piles shall be carried out continuously. In exceptional cases of interruption of concreting the tremie shall not be taken out of the concrete under any circumstances. The tremie pipe shall be raised and lowered slowly from time to time to prevent it from getting stuck in the concrete while ensuring its lower end does not come out of concrete. The concreting shall be resumed before final setting time of concrete, which shall be established before the start of the piling operation. For achieving longer setting time of the concrete, super plasticizers having retarding properties/retarders can be used. If any of these requirements are not met, the pile shall be rejected.

#### 1204.7.5 *Removal of concrete above cut-off level*

It is desirable that the concrete above cut-off level, is removed before the concrete is set. This may be done manually or by specially made bailer or other device. Such removal of concrete helps in preventing the damage of the good concrete below the cut-off level, which results from chipping by percussion method.

The removal of concrete shall be within ± 25 mm from the specified cut off level, preferably on the minus side. After removal of such concrete, the concrete shall be compacted with rammer with spikes or vibrated.

In case the concrete is not removed before setting, a groove shall be made on outer perimeter by rotary equipment before chipping by percussion method.

The minimum embedment of cast in-situ concrete piles into pile cap shall not be less than 50 mm. Any defective concrete at the head of the completed pile shall be cut away and made good with new concrete. The clear cover between the bottom reinforcement in pile cap from the top of the pile shall be not less than 25 mm. The reinforcement in the pile shall be exposed for full anchorage length to permit it to be adequately bonded into the pile cap. Exposing such length shall be done carefully to avoid damaging the rest of the pile.

### 1204.8 Timber Piles

The Engineer shall stamp each pile on the butt with a stamp which shall make an impression that is readily legible. Treated timber piles will be inspected by the Engineer after treatment. Untreated timber piles may be used as test piles. Treated timber piles shall be driven within 6 months after treatment.

Timber piles shall be furnished with tip protection and protected by the use of steel straps. Tip protection shall be suitable for use on timber piling of the size to be driven. Details of tip protection shall be furnished to the Engineer for review and approval before driving piles. Not less than 2 separate steel straps shall be placed within 600 mm of the butt of each pile after the pile is square cut. Not less than 2 separate steel straps shall be placed within 300 mm of the tip of each pile. Additional intermediate steel straps shall be placed at intervals of not more than 3 m, measured along the length of the pile.

Timber piles which are to be capped shall be separately cut off so that true bearing is obtained on every pile. Piles inaccurately cut off shall be replaced. Splicing of timber piles shall not be permitted except by written permission of the Engineer.

## 1204.9 Pile Driving

### 1204.9.1 *Driving equipment*

Piles or their casings may be driven with any type of drop hammer, diesel hammer or single-acting steam or compressed air hammer, provided they penetrate to the prescribed depth to attain the designed resistance without being damaged. The weight or power of the hammer should be sufficient to ensure a penetration of at least 5 mm per blow unless rock has been reached. It is always preferable to employ the heaviest hammer practicable and to limit the stroke, so as not to damage the pile. The minimum weight of the hammer shall be 2.5t. In the case of precast concrete piles, the mass of the hammer shall be not less than 30 times the mass of 300 mm length of pile.

Steam or air hammers shall be furnished along with boiler or air compressor of capacity at least equal to that specified by the manufacturer of the hammers. The boiler or air compressor shall be equipped with an accurate pressure gauge at all times. The valve mechanism and other parts of steam, air or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed, will be obtained. Inefficient steam, air or diesel hammers shall not be permitted to be used on the work.

### 1204.9.2 *Driving procedure*

Details of the equipment and the method proposed for driving the piles shall be submitted for scrutiny and approval of the Engineer. Piles shall be installed from firm ground or from temporary supports or from fixed platform. The arrangement shall provide sufficient rigidity to ensure accuracy of pile driving under all conditions of tide, stream flow or hammer drop.

During driving the top of pile shall be protected by a suitable helmet of substantial steel construction. The helmet shall provide uniform bearing across the top of the pile and shall hold the pile centrally under the hammer. No pile shall be driven unless inspected and approved by the Engineer.

Piles shall be driven from a fixed frame of sufficient rigidity to ensure accuracy of driving within specified tolerances. The force of the hammer shall be directed centrally and axially during driving. Forces producing undue bending or torsional stresses in piles shall not be applied during driving.

The stroke of a single acting or drop hammer shall be limited to 1.2 m unless otherwise permitted by the Engineer. A shorter stroke may be necessary when there is danger of damaging the pile.

Piles shall not be bent or sprung into position but shall be effectively guided and held on line during the initial stages of driving. Attempts to correct any tendency for the pile to run off line by the application of significant horizontal restraint will not be permitted. Shortly after the commencement of driving and at regular intervals throughout the driving operation, checks shall be made to ensure that the pile frame does not exert any undue lateral force on the pile due to restraint within the helmet.

If the indications are that a pile will finish outside the specified tolerances, driving operations on that pile will cease. The pile shall be withdrawn, the hole filled and the pile re-driven at the cost of the Contractor.

To avoid the possibility of premature "set-up", pile driving shall be continuous in the later stages, without any deliberate stops. Delays of an hour or less may lead to significant "set-up" in piles i.e. resistance to further driving increases after driving is stopped.

If any pile is damaged in any way during driving, it shall be repaired or replaced as directed by the Engineer, at the cost of the Contractor. If during driving, the head of a pile is damaged to the extent that further driving is not possible, the head shall be cut off and driving continued. The cost of cutting off shall be borne by the Contractor and where, as a result of such cutting off the head, the pile is too short, the Contractor, shall, at his own cost, supply and splice on sufficient length of pile to restore the pile to its correct length.

Piles should be driven to the minimum acceptable penetration shown on the drawings. This may require pre-boring and/or jetting with the approval of the Engineer.

Piles shall be driven to nominal refusal or the required ultimate dynamic capacity mentioned on the drawings or until the top of the pile is at the level required and specified on the drawing whichever gives the lowest toe elevation. The Engineer's decision in these matters shall be final. Nominal refusal shall be taken as equivalent to 25 mm total penetration for the final 20 blows using a hammer of driving energy as specified and shall be used as the criterion for acceptance for piles founded on rock. Severe driving which results in an average set per blow less than 0.5 mm will not be permitted.

Where hard drilling is encountered because of dense strata or obstructions located above the predetermined pile tip level, nominal refusal shall not be considered to have been achieved unless the Engineer is satisfied that the total number of blows, as the average driving resistance specified for nominal refusal, indicates that further driving will not advance the pile through dense strata or obstructions.

The pile shall be driven as accurately as possible to the vertical or to specified batter. Straining the pile into position can damage it and the driving equipment should be adjusted as much as possible to follow the position of the pile. Any deviation from the proper alignment shall be noted and promptly reported to the Engineer. If the deviation is to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile tips, such a pile shall, at the discretion of the Engineer, be replaced or supplemented by an additional pile.

Care shall be taken not to damage the pile by over-driving. Any sudden change in the rate of penetration which cannot be ascribed in the nature of the ground shall be noted and its cause ascertained, if possible, before driving is continued.

While withdrawing a casing used in the construction of cast in-situ pile, consideration shall be given to the possibility of damaging any other nearby pile. The danger of damaging is greater in compact soils than in loose soils. No pile shall be bored or driven within 3 m of a newly cast pile until at least 24 hours after completion of its installation.

Driving piles in loose sand tends to compact the sand which in turn increases the skin friction. Therefore, driving a number of friction piles in a group shall proceed outward from the centre as otherwise it will be difficult to drive the inner piles to the same depth as the others.

In the case of stiff clay also, the driving for a group of piles shall proceed outward from the centre. However, in case of very soft soil, the driving may proceed from outside to inside, so that the soil is restrained from flowing out during driving operations.

If there is a major variation between the depth at which adjacent foundation piles in a group meet refusal, a boring shall be made nearby to ascertain the cause of this difference. If the boring shows that the soil contains pockets of highly compressive material below the level of the shorter pile, it will be necessary to enforce penetration of all the piles to a level below the bottom of the zone which shows such pockets.

### **1204.9.3** *Pre-boring and jetting*

Driving of the piles may be assisted by pre-boring holes or by the use of jets or both, subject to the approval of the Engineer. These may be used essentially to achieve the minimum penetration shown on the drawings where such penetration is not reached under normal conditions of driving

The diameter of the hole shall not be greater than the diagonal dimension of the pile less 100 mm.

The maximum depth of the pre-boring shall be such that the specified set (or less) is obtained when the toe of the pile is at founding level. Pre-boring shall be as approved by the Engineer and shall be carried out only up to a level of one metre above the founding level. The pile shall be driven for at least one metre below the pre-bored hole. To ensure that the pile is properly supported laterally in the hole, any space remaining around the pile at the ground level after driving is completed, shall be backfilled with approved granular material.

When water jetting is used, at least two jets shall be attached to the pile symmetrically. The volume and pressure of water at the outlet nozzles shall be sufficient to freely erode material, adjacent to the toe of the pile. The maximum depth up to which jetting is carried out, shall be such that the specified set (or less) is obtained when the toe of the pile is at founding level. Jetting shall cease as directed by the Engineer and shall proceed only up to 1 m above the founding level. The pile shall be driven at least 1 m below the pre-bored hole.

To avoid very hard driving and vibration in materials such as sand, jetting of piles by means of water may be carried out only with the express permission of the Engineer and in such a manner as not to impair the bearing capacity of piles already in place, the stability of the soil or the safety of any adjoining buildings. Details of the arrangement for jetting shall be got approved from the Engineer in advance.

If large quantities of water are used for jetting, provision shall be made for collecting and draining away of water when it comes to the surface of the ground, so that the stability of the piling plant is not endangered by the softening of the ground.

Jetting shall be stopped before completing the driving which shall always be finished by ordinary methods. Jetting shall be stopped if there is any tendency for the pile tips to be drawn towards the pile already driven owing to the disturbance of the ground.

### 1204.10 Raker (Inclined) Piles

The maximum rake to be permitted in piles shall not exceed the following:

i) 1 in 6 for all bored piles

ii) 1 in 6 for cast in-situ piles

iii) 1 in 4 for precast driven piles

### 1204.11 Pile Tests

### 1204.11.1 *Initial load test*

The number of initial tests shall be determined by the Engineer taking into consideration the bore log and soil profile, design length, pile diameter and design pile capacity. However, it shall not be less than two for each category.

Initial load test for axial load capacity, including uplift capacity if required, on trial piles of the same diameter as of the design pile, shall be carried out after 28 days design strength is achieved. The testing shall be done as per the procedure laid down in IS:2911, Part-IV. The load test shall be conducted for not less than 2½ times the design load. The initial load test shall be cyclic load test for piles deriving strength from end bearing and side friction. The maintained load test can be performed for end bearing piles which do not rely on friction and for piles socketed in rock;

If the initial load test gives a capacity greater than 25 percent of the capacity calculated by static formula and if it is desired to take benefit of the higher capacity, another two load tests shall be carried out to confirm the earlier value and minimum of the three shall be considered as initial load test value. The number of initial tests shall be determined by the Engineer taking into consideration the bore log and soil profile.

Lateral load tests shall be carried out for estimating the lateral load capacity of the piles. The test procedure shall be carried out as per IS:2911 part IV. However the permissible deflection shall be as per IRC:78.

In particular cases where upper part of pile is likely to be exposed later due to scour, then the capacity contributed by that portion of the pile during load test, shall be accounted for.

### 1204.11.2 *Routine load tests*

Routine load test shall be carried out at actual locations of foundations of bridges to re-confirm or modify the allowable loads. The lateral load test may be conducted on two adjacent piles. However, results of routine load tests shall not be used for upward revision of design capacity of piles. The minimum number of tests to be conducted for confirming the capacity shall be as per **Table 1200.3** :

**Table 1200.3 Minimum Number of Tests**

| Total Number of Piles for the Bridge | Minimum Number of Test Piles |
|---|---|
| Upto 50 | 2 |
| 50-150 | 3 |
| Beyond 150 | 2% of total piles (fractional number rounded to next higher integer number) |

***Note:*** The number of tests may be judiciously increased depending upon the variability of foundation strata. For determining the number of piles to be tested for the routine test the total number of piles under all structures of left and right carriageway and the service road shall be taken together, provided length and diameters of the piles are the same.

### 1204.11.3 *Permissible overload*

While conducting routine test on one of the piles belonging to a pile group, if the pile capacity is found to be deficient (based on the settlement criteria of 12 mm for piles of diameter up to and including 600 mm and 2 percent of the pile diameter for piles of diameter more than 600 mm at 1.5 times the design load), an overload up to 10 percent of the capacity may be allowed.

For a quick assessment of pile capacity, strain dynamic tests may be conducted after establishing co-relation using the results of load tests. However, results of strain dynamic tests shall not be used for upward revision of design capacity of pile. Detailed guidelines and references are given in IRC:78. These methods can be followed.

To have a fairly good idea about the quality of concrete and construction defects like voids, discontinuities etc, pile integrity tests are extensively conducted. Detailed guidelines in this connection are given in IRC:78.

### 1204.12 Pile Cap

Casting of pile cap should be at a level higher than low water level unless functionally required to be below low water level. In such cases dewatering shall be resorted to allow concreting in dry conditions. Pile caps shall be of reinforced concrete. A minimum offset of 150 mm shall be provided beyond the outer faces of the outermost piles in the group. If the pile cap is in contact with earth at the bottom, a leveling course of minimum 80 mm thickness of M15 nominal mix concrete shall be provided. In marine conditions or areas exposed to the action of harmful chemicals, the pile cap shall be protected with a coating such as bituminous based coal tar epoxy or epoxy based coating or with suitable anti corrosive paint. Concrete with high alumina cement shall not be used in marine environment.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. A portion of pile top may be stripped of concrete and the reinforcement anchored into the cap. Manual chipping may be permitted three days after casting of pile, while pneumatic tools for chipping shall be permitted only seven days after casting of pile. The top of pile after stripping shall project at least 50 mm into the pile cap.

The top of concrete in a pile shall be brought above cut-off level to permit removal of all laitance and weak concrete before pile cap is laid. This will ensure good concrete at the cut-off level.

### 1204.13 Important Considerations, Inspection/Precautions for Different Types of Piles

#### 1204.13.1 *Driven cast in-situ piles*

Specialist literature and the guidelines from the pile construction industry shall be consulted regarding the method of installation, equipment and accessories for pile driving and recording of data.

During installation of piles, the final “set” of penetration of pile per blow of hammer shall be checked taking an average of last 10 blows.

The pile shoes which may be of either cast iron conical type or mild steel flat type shall have double reams for proper seating of the removable casing tube inside the space between the reams.

Before commencement of pouring of concrete, it shall be ensured that there is no ingress of water in the casing tube from the bottom. Further, adequate control during withdrawal of the casing tube is essential so as to maintain sufficient head of concrete inside the casing tube at all stages of withdrawal.

Concrete in piles shall be cast up to a minimum height of 600 mm above the designed top level of pile, which shall be stripped off at the time of construction of pile cap.

#### 1204.13.2 *Bored cast in-situ piles*

While concreting uncased piles, voids in concrete shall be avoided and sufficient head of concrete is to be maintained to prevent inflow of soil or water into the concrete. It is also necessary to take precautions during concreting to minimize the softening of the soil by excess water. Uncased cast in-situ piles shall not be allowed where mudflow conditions exist.

The drilling mud such as bentonite suspension shall be maintained at a level sufficiently above the surrounding ground water level throughout the boring process, to ensure the stability of the strata which is being penetrated until the pile has been concreted.

Where bentonite suspension is used to maintain the stability of the borehole, it is essential that the properties of the material be carefully controlled at stages of mixing, supply to the borehole and immediately before concrete is placed. It is usual to limit :

i) The density of bentonite suspension to 1.05 g/cc

ii) The marsh cone viscosity between 30 and 40

iii) The pH value between 9.5 and 12

iv) The silt content less than 1 percent

v) The liquid limit of bentonite not less than 400 percent

These aspects shall act as controlling factors for preventing contamination of bentonite slurry for clay and silt.

The bores shall be washed by bentonite flushing to ensure clean bottom at two stages viz. after completion of boring and prior to concreting after placing of reinforcement cage. Flushing of bentonite shall be done continuously with fresh bentonite slurry till the consistency of inflowing and outflowing slurry is similar.

For very long or large diameter piles, use of retarding plasticizer in concrete is desirable.

For large diameter piles, it may be essential to conduct non-destructive pile integrity tests to evaluate integrity of the pile.

Where possible, it may be desirable to grout the base of pile with cement slurry under suitable pressure after concrete in the pile attains the desired strength. For this purpose, conduit pipes with easily removable plugs at the bottom end should be placed in the bore along with reinforcement cage before concreting.

### 1204.14 Tolerances

### 1204.14.1 *Permissible tolerances for piles*

**i) Precast Concrete Piles:**

a) Variation in cross-sectional dimensions : ± 5 mm

b) Variation in length : ± 25 mm

c) Surface irregularities measured with 3 m straight edge : 5 mm

d) Bow for total length of pile in mm 1 mm/m length of pile limited to 20 mm

**ii) Driven Piles**

a) Variation in cross-sectional dimensions : +50 mm, -10 mm

b) Variation from vertical for vertical piles : 1 in 150

c) For vertical piles deviation at piling platform level : 75 mm

d) Variation of level of top of piles : ± 25 mm

**iii) Bored Piles**

a) Variation in cross-sectional dimensions : +50 mm, -10 mm

b) Variation from vertical for vertical piles 1 in 150

c) For vertical piles deviation at piling platform level : 75 mm

d) Variation of level of top of piles : ± 25 mm

**iv) For raker piles from specified rake** : 1 in 25

### 1204.14.2 *Permissible Tolerances for Pile Caps*

a) Variation in dimensions : +50 mm, -10 mm

b) Misplacement from specified position in plan : 15 mm

c) Surface irregularities measured : 5 mm with 3 m straight edge

d) Variation of level of top of piles : ± 25 mm

### 1204.15 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria and requirements.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

### 1204.16 Measurements for Payment

For supply of precast concrete, timber or steel piles of specified cross-section, the measurement shall be in metres of the length of piles ordered in writing by the Engineer measured from the head to the butt of the shoe or the tapered point. Reinforcement in precast concrete piles shall not be measured for payment.

For cast in-situ driven and bored concrete piles of specified cross-section, the measurement shall be the length in metres of the accepted pile that remains in the finished structure complete in place. Reinforcement in cast in-situ driven and bored concrete piles shall be measured for payment as per Section 800 of these Specifications.

Routine and Initial Pile Load Tests shall not be measured for payment.

For installation of the pile, i.e. by drilling in the case of precast concrete, timber, steel and cast in-situ driven piles, and by boring in the case of cast in-situ bored pile, the measurement shall be the length in metres that remains in the finished structure complete in place, limited to that shown on drawings or as directed by the Engineer. No distinction shall be made for penetration through hard strata or rock and socketing into rock.

For steel liners / casing shown on the drawings to be permanently left in place, the measurement shall be by weight in tonnes that remains in the finished structure complete in place, limited to that shown on drawings or as directed by the Engineer.

For the pile cap, the quantity of concrete shall be measured in cubic metres as per Section 800 of these Specifications and reinforcement in pile cap shall be measured in tonnes as per Section 1000 of these Specifications.

### 1204.17 Rate

The contract unit rate for supplying precast concrete, timber or steel piles shall include cost of all labour, materials, tools and equipment, and other work involved in making or fabricating the pile complete as shown on the drawing, and where required its loading, transport, delivery to site, unloading and stacking at the place indicated by the Engineer. The cost of reinforcement including treatment as per Section 800 of these Specifications in precast concrete shall be deemed to be included in the quoted rate for supply of piles. The contract unit rate shall also include costs of all labour, materials, equipments and all other incidentals involved in conducting routine and initial pile load tests, including installation of piles for initial load tests.

The contract unit rate for cast in-situ driven and bored piles shall include the cost of concrete and all other items as per Section 800 of these Specifications. The contract unit rate shall also include costs of all labour, materials, equipments and all other incidentals involved in conducting routine and initial pile load tests, including installation of piles for initial load tests.

The contract unit rate for reinforcement in cast in-situ driven and bored piles shall be as per Section 1000 of these Specifications.

The contract unit rate for installation of piles shall include full compensation for furnishing all labour, materials, tools and equipment, and incidentals for doing all the works involved in driving timber, precast concrete and steel piles, driving or making bores for cast in-situ driven and bored concrete piles, cutting off pile heads, all complete in place to the specified penetration of piles. Providing temporary liner/casing and its withdrawal and placing reinforcement in position shall also be deemed to be included in the rate for installation of piles and no additional payment shall be made for the same.

The contract unit rate for permanent steel liners shall include cost of all labour, fabrication, treatment to the liner and placing the steel liner to the required depth as shown on the drawings and as as directed by the Engineer.

The contract unit rate for concrete in pile cap shall cover all costs of labour, materials, tools, plant and equipment, formwork and staging including placing in position, sampling and testing and all as per Section 800 of these Specifications. Unit rate quoted shall also include the treatment to be given to the surfaces of the pile cap. Reinforcement in the pile cap shall be paid for separately as per Section 1000 of these Specifications.

## 1205 WELL FOUNDATIONS

### 1205.1 General

The work shall consist of construction of well foundation, taking it down to the founding level by sinking through all kinds of substrata, plugging the bottom, filling the well with approved material, plugging the top and providing a well cap, in accordance with the details shown on the drawings and as per these specifications, or as directed by the Engineer.

Wells may have a circular, rectangular or D-shape in plan and may consist of one, two or more compartments in plan.

In case of well foundations of size larger than 12 m diameter, supplemental construction specifications will be necessary.

The subsurface geotechnical investigations to be carried out before commencement of work of well foundations. In case blasting is anticipated for facilitating sinking through difficult strata such as boulders and rock, special protective / strengthening measures for the curb and steining of the well will be required.

Pneumatic sinking may have to be resorted to in cases where the well has to be sunk through rock/hard strata or where there are obstacles such as tree trunks, large sized boulders etc, which cannot be removed by open dredging. In such cases, the decision regarding adoption of pneumatic sinking shall be taken on the basis of results of confirmatory bores and as directed by the Engineer.

### 1205.2 Setting out and Preparations for Sinking

Necessary reference points shall be accurately fixed to mark x-x axis along the direction of traffic and y-y axis normal to direction of traffic. Such reference points shall be away from the zone of blow-ups or possible settlements which may result from well sinking operations and shall be connected to the permanent stations with the base line on the banks. The centre of the individual wells shall be marked with reference to these stations. The distance between the wells shall be checked with the help of precision instruments. A temporary benchmark shall be established near the well foundation, away from the zone of blow-ups or possible settlement. The bench mark shall be checked regularly with respect to the permanent bench mark established at the bridge site.

For wells located on the banks of the river or in dry area, the bed may be prepared by excavating the soil up to 1.5 m, followed by leveling and dressing before placing the cutting edge.

For wells which are to be located in water, a sand island shall be constructed for laying the cutting edge and well curb. Sand islands are practicable for water depths of up to 5 m under stable bed soil conditions. Where the depth of water is greater than 5 m or in fast flowing rivers or for locations where soil is too weak to sustain sand island, floating caissons may have to be adopted.

The plan dimensions of sand islands shall be such as to have a working space of at least 2 m all around the steining of the well. Sand islands shall be maintained to perform their functions, until the well is sunk to a depth below the original bed level at least equal to the depth of water at that location.

The sand island shall be held in position and protected against scour by means of wooden ballies properly braced or sheet piles. The top level of the sand island to be decided by the Engineer, shall be sufficiently above the prevailing water level so that it is not affected by wave action.

Equipment shall be deployed for construction of well foundation as required and as directed by the Engineer. Generally, the following equipment may be required for the work:

i) crane with grab buckets – capacity 0.5 cum to 2.0 cum
ii) submersible pumps
iii) air compressors, air locks and other accessories where pneumatic sinking of well is anticipated
iv) chisels of appropriate sizes
v) aqua-header for cutting rocky strata
vi) diving helmets and accessories
vii) batching plants for concrete production
viii) equipment for transportation, placing and compaction of concrete

### 1205.3 Cutting Edge

The cutting edge shall be made from structural steel sections conforming to Section 1000 of these Specifications and shall be strong enough to facilitate sinking of the well through the type of strata expected to be encountered. The weight of the cutting edge shall not be less than 40 kg per metre length. It shall be properly anchored into the well curb as shown on the drawing.

When there are two or more compartments in a well, the bottom of the cutting edge of the inner walls shall be kept at about 300 mm above that of outer walls.

In V shaped cutting edge, the inclined plate should meet the vertical plate in such a way that full strength connection by welding is feasible.

The parts of cutting edge shall be erected on level firm ground about 300 mm above prevalent water level. Temporary supports shall be provided to facilitate fabrication and for maintaining the assembly in true shape. The fabrication may be carried out in the shop or at site. Steel sections shall not be heated and forced into shape. However, “V” cuts may be made in the horizontal portion, uniformly throughout the length, to facilitate cold bending. After bending, such “V” cuts should be closed by welding. Joints in the lengths of structural sections, unless otherwise specified, shall be fillet welded using single cover plate to ensure the requisite strength of the original section.

### 1205.4 Well Curb

The well curb shall be such that it will offer minimum resistance while sinking but will be strong enough to be able to transmit superimposed loads from the steining to the bottom plug. The shape and outline dimensions of the curb shall be as shown in IRC:78. The internal angle of the curb shall be about 30° to 37° depending upon geotechnical data of the strata through which the well is to be sunk.

The well curb shall be in reinforced concrete having concrete mix in accordance with Tables 800.2 and 800.3 and with minimum reinforcement of 72 kg/cum excluding bond rods.

The steel shall be suitably detailed to prevent spreading and splitting of curb during sinking. The outer face of the curb shall be vertical. The bottom ends of vertical bond rods of steining shall be fixed securely to the cutting edge with check nuts or by welds. Concreting of the well curb shall be done in one continuous operation.

Steel formwork for well curb shall be fabricated strictly in conformity with the drawing. The formwork on outer face of curb may be removed within 24 hours after concreting while that on inner face shall be removed only after 72 hours.

In case blasting is anticipated, the inner face of the well curb shall be protected with steel plates of thickness not less than 10 mm up to the top of the well curb. If considered necessary, the inner face of steining may also be protected with steel plates of 6 mm thickness up to a height of 3 m above the top of the well curb or as specified by the Engineer. The curb as well as 3 m height of steining above the curb, shall be provided with additional hoop reinforcement of 10 mm diameter bars at 150 mm spacing. Additional hoop reinforcement shall be provided in the steining for a further height of up to two times the thickness of steining above the plates, so as to avoid cracking which may arise on account of sudden change in the effective section due to curtailment of plate.

### 1205.5 Floating Caissons

Floating caissons are generally fabricated at or near the banks on dry land or in dry docks and then towed into position. For floating caissons, a detailed method statement covering fabrication, floating and sinking operations, shall be prepared and furnished to the Engineer. Such statement shall include the total tonnage of steel involved, fabrication and welding specifications, list of materials and plant and a description of operations and manpower required for the work.

Floating caissons shall be of structural steel conforming to Section 1000 of these Specifications. The joints of the fabricated structure shall be absolutely leak-tight and shall be checked against leakage before floating and being towed to site. The reinforcement of the curb and steining of the well shall be fixed inside the shell by welding before the caisson is floated. Stability of floating caissons shall be ensured against overturning and capsizing under the action of water current, wave pressure and wind while being towed and kept in position. To maintain the stability of the shell while being floated, it may be provided with ballast in the form of water filling up to required level or filling with small amount of concrete. It shall be ensured that the draught of the floating caisson is always less than the depth of water available, so as to facilitate its smooth hindrance-free movement while being towed.

Height of caisson shall be planned to ensure that at any given time, at least one metre of the shell shall be above water level. In case the location is affected by the action of waves, the height shall be suitably increased to avoid water spilling into the caisson. In case the bed has soft soil, the caisson shall be provided with 3 to 5 metres of additional height, as it may sink by itself after grounding in bed. Simultaneous sinking and concreting is required to prevent caisson from tilting. In sandy stratum especially with strong water current, appropriate additional height of caisson is necessary for accommodating local scour.

The floating caisson shall be held in position against untoward movement by wire ropes/ chains, using winches mounted on stationary suitable platforms/buoys or similar anchoring systems. Anchoring in minimum three directions, shall be provided to prevent unacceptable longitudinal and lateral movement. The anchoring system shall permit small movements in order to facilitate correct positioning of the caisson at the exact location of the well and until the stage when it is just getting grounded. Special care is necessary where variation in water level is frequent, e.g. in tidal zones.

After being held in correct position, concreting of the floating caisson shall be commenced. The concrete mixed in batching plants, shall be carried to the floating caisson on barges and placed in position through concrete pumps or tremie. When large volumes of concreting are involved, the batching plant concrete pump, crane etc, may all be mounted on a barge kept in the vicinity of the caisson. As no vibration is possible inside the shell, it shall be ensured that the concrete has a slump of 150 to 200 mm; alternatively, self-compacting concrete can be used. The concrete shall be carefully placed uniformly all around the caisson so that it settles vertically without any tendency to tilt.

### 1205.6 Well Steining

The dimensions, shape, concrete strength and reinforcements of the well steining shall strictly conform to those shown on the drawings. The formwork shall preferably be of MS sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or MS sheets.

The height of the first lift of steining to be cast above the well curb shall not be more than 2 m and subsequent lifts shall not exceed the diameter of the well or the depth of well to be sunk below the bed level at any time. For stability, the first lift of steining shall be cast only after sinking the curb at least partially. Concreting of steining may be carried out in subsequent lifts of about 2 to 2.5 m. Attempts should be made to minimize the number of construction joints. The concreting layers shall be limited to 450 mm restricting the free fall of concrete to not more than 1.5 m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

The steining of the well shall be built in one straight line from bottom to top such that if the well is tilted, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb bob or spirit level shall not be used for alignment. After sinking of a stage is complete, damaged portions of steining at top of the previous stage shall be properly repaired before constructing the next stage.

For measuring the height of steining, it shall be marked with at least 4 gauges, two in traffic direction and two normal to traffic direction, distributed equally on the outer face of the well. The marking shall be in the form of a 100 mm wide strip painted on the steining, with every metre marked in black paint. Marking of the gauges shall be done carefully and accurately with a steel tape, starting with zero at the bottom of the cutting edge. The marking shall be continued upwards as each lift of steining is added.

After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Engineer will direct and the Contractor shall execute the remedial measures, if required, before acceptance of the well steining. In case the well is found to be unacceptable even after remedial measures are carried out, then it shall stand rejected.

### 1205.7 Well Sinking

### 1205.7.1 *General*

The well shall be sunk true and vertical through all types of strata. No well shall be permitted to be placed in a pre-dredged hole.

Sinking or loading of the well with kentledge shall be commenced only after the steining has been cured for at least 48 hours or as specified in the drawings.

The well shall be sunk by excavating the material uniformly from inside the dredge hole using cranes with grab buckets of appropriate capacity. Use of water jetting, explosives and divers may be adopted for sinking of wells through difficult strata, with prior approval of the Engineer. Well sinking can also be carried out by jack down method.

Normally dewatering of well should not be permitted as a means for sinking the well. It shall never be resorted to if there is any danger of sand blowing under the well. Dewatering shall however be done when well is to be founded in rock. Pneumatic sinking may have to be resorted to where obstacles such as tree trunks, large sized boulders etc are met or when there is hard strata which cannot be removed by open dredging. The necessity for adopting pneumatic sinking shall be decided by the Engineer.

Complete history of sinking of each well giving details of concreting, sinking and problems met, if any, shall be maintained in the format given in **Annexure-1200/I**.

### 1205.7.2 *Sand blows in wells*

Dewatering of the well shall not be carried out if sand blows are expected. Any equipment or men working inside the well, shall be brought outside the well as soon as there are any indications of sand blow occurring. Sand blow can often be minimized by keeping the level of water inside the well higher than the water table and also by adding heavy kentledge.

### 1205.7.3 *Use of kentledge for sinking of well*

Kentledge shall be placed in an orderly and safe manner on the loading platform and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well.

Where tilt has occurred or there is a danger of well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

### 1205.7.4 *Use of water jetting*

Water jetting can be used to facilitate sinking of wells through clay/hard strata. The decision regarding use of water jetting shall be taken at the design stage itself, based on geotechnical investigations which may be indicating presence of hard, clayey strata. For carrying out water jetting, the required number of steel pipes of 40 to 50 mm diameter shall be embedded in the steining of the well, spaced evenly around its periphery. The bottom of the steel pipe shall taper down to a nozzle exiting in the sloping face of the well curb. The diameter of the nozzle shall be 6 mm. The steel pipe shall be kept about 1 m above the top of each lift of steining, so that it can be extended by means of suitable couplers before the next lift of steining is cast. When the well reaches the hard strata and the need for water jetting arises, the tops of the embedded pipes shall be connected to pumps of required capacity for pumping in water at high pressure. The water jet issuing from the nozzle of the pipe under high pressure, cuts through the hard material and loosens it, permitting the well to sink at a faster rate than would otherwise have been possible. When water jetting is to be adopted, the Contractor shall furnish a method statement for approval of the Engineer covering all aspects of the work including the number, capacity and location of the high pressure pumps and other ancillaries required for executing the work.

### **1205.7.5** *Use of jack down method*

The jack down method of sinking shall be adopted as per requirement or as directed by the Engineer. The first step shall be to install ground anchors outside the periphery of the well. The number, location and depth of ground anchors are decided based on the properties of the surrounding soil to develop the necessary resisting force through skin friction. The drill holes of about 150 mm diameter along with casings shall be taken down to a depth of about 20 m or more below the founding level of the well, depending on requirements of design. After the holes have been drilled to the required depth, prestressing strands of adequate diameter and capacity are cut to the desired length and lowered into the holes. The holes shall then be grouted with cement slurry with non-shrink additive. Once the grouting is completed till the ground level, the casing is removed. The removal of the casing shall be done before the grout sets. In case rock is met with, the anchors shall be socketed into rock.

Heavy duty pressurization girders fabricated of steel, shall be placed over stools resting on the steining of the well, against which the hydraulic jacks connected to the ground anchors, can exert pressure to push the well down. The hydraulic jacks shall be of capacity 500 T or more as per requirement. Before applying pressure from the jacks, 1 m deep sump is created inside the well by dredging. Pressure on different jacks is exerted in such a manner as to neutralize any tendency of the well to tilt. With the use of the jacks and controlled dredging, high rates of sinking can be achieved and the chances of sand blowing can also be reduced.

For use of jack down method of sinking, the Contractor shall furnish a method statement for approval of the Engineer, giving full details of construction of ground anchors, fabrication of pressurizing girder, type, number and capacity of jacks to be used, method of dredging and application of jack down force and all other relevant aspects for proper execution of the work.

### **1205.7.6** *Use of explosives*

Mild explosive charges may be used as an aid for sinking of the well. All prevalent laws concerning handling, storing and using of explosives shall be strictly followed. All safety precautions shall be taken as per IS:4081 “Safety Code for Blasting and related Drilling Operations”, to the extent applicable, whenever blasting is resorted to.

When the likelihood of resorting to blasting is predicted in advance, protection of the bottom portion of the well shall be done as per Clause 1205.4.

Blasting of any sort shall be done only with prior permission and in the presence of the Engineer. Blasting shall not be done before the concrete in the steining has hardened sufficiently and is more than 7 days old.

After blasting operations are completed, the well curb and steining should be examined for any cracks and remedial measures taken if required.

If blasting has been done after the well has reached the design foundation level, normally 24 hours shall be allowed to lapse before the bottom plug is laid.

The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances of any damage to the curb or to the steining of the well. A minimum sump of 1 m depth should be made before resorting to blasting. Use of large charges, 0.7 kg or above, may not be allowed, except under expert direction and with the permission of the Engineer. The pattern of charges may be suitably arranged with delay detonators so as to reduce the number of charges fired at a time. The burden of the charge may be limited to 1 m and the spacing of holes may normally be kept as 0.5 m to 0.6 m.

There should be no equipment inside the well nor shall there be any worker in the close vicinity of the well at the time of exploding the charges.

If rock blasting is to be done for seating of the well, the damage caused by flying debris should be minimised by covering blasting holes with rubber mats before detonating the charge.

### **1205.7.7** *Use of divers*

Divers may be used for removal of obstructions during sinking, carrying out rock blasting and for inspection. All safety precautions shall be taken as per any acceptable safety code or any statutory regulations in force, when divers carry out work under water in the well.

Only persons trained in diving operations shall be employed after being certified fit for diving by an approved doctor. They shall work under expert supervision. The raising of the diver from the bottom of wells shall be controlled so that decompression rate conforms to the rate as laid down in relevant regulations.

The diving and other equipment shall be of acceptable standard and certified to this effect by an approved independent agency. They shall be well maintained as per requirements for safe use.

Arrangement for ample supply of low pressure clean cool air shall be ensured through an armoured flexible hose pipe. Standby compressor shall be provided to cover the contingency of breakdown of the compressor.

Separate high pressure connection shall be made for use of pneumatic tools. Electric lights where provided shall be at 50 volts (maximum).

**1205.7.8** *Precautions during sinking*

i) When wells have to be sunk close to each other and clear distance between them is less than the diameter of wells, sinking shall be taken up on all wells and they shall be sunk alternately, so that, the sinking proceeds uniformly. Simultaneous and even dredging shall be carried out in the wells in such a manner that the difference in the levels of the sump and cutting edge in the adjacent wells does not exceed half the clear gap between them. Plugging of all the wells shall be done together.

ii) During sinking of double D-shaped wells, the excavation in both the dredge holes should be carried out simultaneously and equally.

iii) Bore chart shall be referred to constantly during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

iv) Before seasonal floods, all wells on which sinking is in progress shall be sunk to sufficient depths below the designed scour level. Further, they shall be temporarily filled and plugged so that they do not suffer any tilt or shift during the floods.

v) All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

vi) The dredged material shall not be allowed to accumulate around the well. It shall be dumped and spread, as far away as possible, and then continuously and simultaneously removed, as directed by the Engineer. In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank but on the side on which the river current flows.

vii) Very deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to one-sixth of the outer diameter / least lateral dimension of the well in plan. Normally the depth of sump shall not exceed 3.0 m below the level of the cutting edge unless otherwise specially permitted by the Engineer.

viii) In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction of the Engineer to see that no damage has occurred to it.

xi) Dewatering shall be avoided if sand blows are expected. Any equipment and men working inside the well shall be brought out of the well as soon as there are any indications of a sand-blow.

x) Sand blowing in wells can often be minimized by keeping the level of water inside the well higher than the water table and also by adding heavy kentledge.

xi) In soft strata prone to settlement/creep, the construction of the abutment wells shall be taken up only after the approach embankment for a sufficient distance near the abutment, has been completed.

### 1205.8 Tilts and Shifts

Unless otherwise specified, the tilt of any well i.e. its inclination from the vertical, shall not exceed 1 (horizontal) in 80 (vertical). The shift of the well i.e. the horizontal displacement of the centre of the well at the founding level from its theoretical position, shall not be more than 150 mm in any resultant direction.

Tilts and shifts shall be carefully checked and recorded regularly during sinking operations in the format given in **Annexure-1200/II**. For the purpose of measuring the tilts along the two axes of the bridge, reduced level of the marks painted on the surface of the steining of the well shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axes, with reference to fixed reference points.

Whenever any tilt is noticed, adequate corrective measures like placing eccentric kentledge, pulling, strutting, anchoring or depositing more dredged material outside the tilted face, water/air jetting, shall be adopted before any further sinking. After correction, the dredged material shall be removed and disposed of sufficiently away from the affected well. In case of sinking by jack down method, tilt can be controlled by suitably adjusting jack down pressure on one side.

A pair of wells close to each other has a tendency to come closer while sinking. Timber struts may be introduced in between the steining of these wells to prevent such movement.

Tilts occurring in a well during sinking in dipping rocky strata can be controlled by suitably supporting the curb.

In the event of a well developing tilt or shift beyond the specified permissible values, the Contractor shall have to carry out, at his own cost, suitable remedial measures to the satisfaction of the Engineer, to bring the tilt and shift within permissible values.

If the resultant tilt and shift of any well exceeds 1 in 80 or 150 mm respectively, the well so sunk shall be regarded as not conforming fully to Specification. The Engineer in his sole discretion, may consider accepting such a well, provided:

i) Calculations for foundation pressures and steining stresses, accounting for the actual tilt and shift furnished by the Contractor show that the well is safe. Remedial measures required to bring the stresses within permissible values (such as increase in the dimension of the well cap, provision of dummy weights on the well cap etc.), shall be carried out by the Contractor at his own cost.

ii) The Contractor shall be subjected to reduction in rates as a penalty in accordance with Clause 1205.17(vii).

In case the Engineer, in his discretion, rejects the well, the Contractor shall dismantle the rejected well to the extent directed by the Engineer and remove the debris. Further, the

Contractor shall at his own risk and cost, complete the bridge with modified span arrangement acceptable to the Engineer.

### 1205.9 Seating of Wells

The well shall be uniformly seated on the founding strata. It shall be ensured by test borings that the properties of the soil encountered at the founding level and up to a depth of one and a half times the well diameter, is identical to that adopted in the design. The procedure for test boring shall be in accordance with the provisions of these Specifications. In case the soil encountered is inferior to that adopted in design, the well shall be re-designed by the Engineer adopting the soil properties actually encountered and the founding level intimated to the Contractor, who shall carry out the work accordingly.

In case of seating of wells in hard rocky strata, where the rock profile is steeply sloping, pneumatic methods of sinking may be adopted to seat the well evenly as directed by the Engineer. The decision of adopting pneumatic sinking shall be taken by the Engineer. The cutting edge may also be embedded for a suitable depth in the rocky strata, as decided by the Engineer keeping in view the quality of rock. A sump of depth 300 mm in hard rock or 600 mm in ordinary rock shall be made inside the well by chiselling or blasting as approved by Engineer. Diameter of sump shall be 1.5 m to 2 m less than that of the dredge hole. After the well has been evenly seated on good hard rock, arrangements shall be made to facilitate proper inspection in dry and visible conditions before the bottom plug is laid.

### 1205.10 Bottom Plug

A bottom plug of concrete shall be provided in all wells, the top level of which shall be kept a minimum of 300 mm above the top of the curb, as shown in IRC:78. A suitable sump shall be made below the level of the cutting edge. Before concreting the bottom plug, it shall be ensured that the inside faces of curb and steining have been cleaned thoroughly.

The concrete mix used in bottom plug shall have a minimum cement content of 330 kg per cum with a slump about 150 mm, to permit easy flow of concrete through tremie to fill up all cavities. Concrete shall be laid in one continuous operation till the dredge hole is filled to the required height. For under water concreting, the concrete shall be placed by tremie under still water condition and the cement content shall not be less than 330 $kg/m^3$ inclusive of all mineral admixtures, if added.

In case of grouted concrete, the grout mix shall not be leaner than 1:2. It shall be ensured that the grout fills up all interstices upto the top of the bottom plug by suitable means such as, controlling the rate of pumping etc.

Any dewatering required, shall only be done 7 days after casting of bottom plug.

The concrete production and placement equipment should be sufficient to enable under water concreting within stipulated time. Necessary standby equipment should be available for emergency situation.

Before commencing plugging, all loose material from the bottom of the well shall be removed. Concreting shall be done in one continuous operation till the dredge hole is filled up to the required height and thereafter soundings shall be taken to ensure that the concrete has been laid to the required height. Least disturbance shall be caused to the water inside the well while laying concrete in the bottom plug. The concrete after placing, shall not be disturbed in any way for at least 7 days.

In order to check whether there is any rise in the level of the bottom plug, soundings should be taken at the close of concreting and once every day for the next 3 days.

The soundness of the bottom plug may be tested by dewatering the well to a level 5 m below the surrounding water level and checking the rise of water. For foundation subjected to artesian pressure, the depth of dewatering by 5 m shall be measured form the still water level created inside the well by the construction of false steining. The rate of rise shall preferably be less than 10 cm per hour. In case the rate is higher, suitable remedial measures as directed by the Engineer, shall be taken by the Contractor at his own cost.

### 1205.11 Sand Filling

Sand filling shall commence 7 days after laying of bottom plug. The level of the top of the bottom plug shall be verified before starting sand filling.

The sand shall be clean and free from earth, clay clods, roots, boulders, shingles, etc. and shall be compacted as directed. Sand filling shall be carried out up to the level shown on the drawing or as directed by the Engineer.

### 1205.12 Top Plug

After filling sand up to the required level, a top plug of 300 mm thick concrete of grade M15, shall be provided over it as shown on the drawing or as directed by the Engineer.

### 1205.13 Well Cap

A reinforced cement concrete well cap will be provided over the top of the steining in accordance with the drawing. Formwork will be prepared conforming to the shape of well cap. In case sand filling has been carried out up to the top of the well, the concrete of the well cap may be laid directly on it after it has been suitably levelled. Otherwise, suitable shuttering supported on the inside of the steining, shall be provided for carrying the weight of the green concrete of the well cap.

Concreting shall be carried out in dry condition. A properly designed false steining may be provided where required, to ensure that the well cap is laid in dry condition.

The bottom of the well cap shall be laid preferably as low as possible but above the LWL in the active channel. Where the bed level is higher than the LWL, the top of the well cap may be suitably raised and kept 1m below existing ground level.

Bond rods of steining shall be anchored into the well cap.

### 1205.14 Tolerances

The permissible tilt shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150 mm in any resultant direction.

For the well steining and well cap, the permissible tolerances shall be as follows:

| | | | |
|---|---|---|---|
| i) | Variation in dimension | : | +50 mm, -10 mm |
| ii) | Misplacement from specified position in plan | : | 15 mm |
| iii) | Surface unevenness measured with 3 m straight edge | : | 5 mm |
| iv) | Variation of level at the top | : | ± 25 mm |

### 1205.15 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

### 1205.16 Measurements for Payment

All quantities shall be measured from the drawing, or as directed by the Engineer, excepting those required to be provided by the Contractor at his cost.

i) The structural steel in cutting edge shall be measured in tonnes based on the net weight of metal used in it, as per Section 1000 of these Specifications.

ii) The concrete in curb, well steining and well cap shall be measured in cubic metres in each of the items as per Section 800 of these Specifications.

iii) The steel reinforcement shall be measured in tonnes separately in each of the items, as per Section 1000 of these Specifications.

iv) The measurement for well sinking shall be made in running metres for different depths and in different types of strata (e.g. predominantly sand/clay soil, ordinary rock, hard rock etc) as specified in the contract. The depth of sinking shall be measured from the level specified in the contract. If no level has been specified in the Contract, sinking shall be measured from the low water level or from the level at which the cutting edge was laid, whichever is higher.

v) The quantity of concrete in bottom and top plug shall be measured in cubic metres as per Section 800 of these Specifications.

vi) The quantity of sand filling shall be measured in cubic metres.

vii) Pneumatic sinking, where required, shall be paid as a separate item and shall be measured in cubic metres of material to be excavated.

**1205.17** **Rate**

i) The contract unit rates of structural steel in cutting edge shall cover all costs of labour, material, tools, plant and equipment, including placing in position, sampling and testing, and, supervision, all as per Section 1000 of these Specifications.

ii) The contract unit rates for concrete in curb, steining, bottom plug, top plug and well cap, shall cover all costs of labour, material, tools, plant and equipment, formwork and staging including placing in position, sampling and testing, and, supervision, all as per Section 800 of these Specifications and as described in this Section.

iii) The contract unit rates for reinforcement in curb, steining, and well cap, shall cover all costs of labour, material, tools, plant and equipment, including bending to shape, placing in position, sampling, testing and supervision, all as per respective Section 1000 of these Specifications and as described in this Section.

iv) The contract unit rates for sand filling shall cover all costs of labour, material, tools, plant and equipment, including placing in position and supervision.

v) The contract unit rates for sinking of well shall cover the costs of labour, tools, and equipment and plant and for all operations and other incidentals for sinking of well including seating except pneumatic sinking as described in this Section. The unit rates shall specify the strata such as types of soil, rock, etc. The rate shall cover all testing and supervision required for the work.

vi) The contract unit rate of material to be excavated by pneumatic sinking shall cover all costs of labour, material, tools, plant and other equipment and other incidentals and safety provisions and supervision required for pneumatic sinking as per this Section.

vii) If any well with tilt and/or shift exceeding the permissible values is accepted by the Engineer, the Contractor shall be subjected to a reduction in the rates for the sinking of well as follows:

| S. No. | Amount of Tilt and/or Shift | Percent Reduction on the Rate(s) for Sinking of Whole Well |
|---|---|---|
| a) | Tilt exceeding the specified permissible value but equal to or within 1 in 60 | 5 percent |
| b) | Tilt exceeding 1 in 60 but equal to or within 1 in 50 | 10 percent |
| c) | Shift exceeding the specified permissible value but equal to or within 200 mm | 2 percent |

# 1206 SUBSTRUCTURE

## 1206.1 Description

The work shall cover furnishing and providing masonry or reinforced concrete substructure in accordance with the drawings and as per these Specifications or as directed by the Engineer.

## 1206.2 General

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark so that the substructure is constructed in accordance with the drawings.

Brick masonry, stone and concrete block masonry, concrete, formwork, steel reinforcement/prestressing/structural steel shall conform to Sections 600, 700, 800, 900 and 1000 respectively of these Specifications.

### 1206.2.1 For submersible bridges, the following additional guidelines shall be followed:

i) The masonry substructure shall not be permitted if the height above foundations is more than 7 m.

ii) The locations and levels of pier cap/abutment cap, pedestals, anchorage arrangements (between superstructure and pedestal/pier cap/abutment cap), side bearing pad between superstructure and raised portion of pier cap (thrust wall) and stainless steel rods in pedestal/bearings shall be carefully checked to ensure alignment in accordance with the drawings.

iii) Dry rubble masonry shall not be permitted in retaining walls/breast walls, if required, in approaches of submersible bridges.

iv) Pier cap including raised portion/stopper (thrust) wall, abutment cap and pedestals shall be given streamline shape as shown on the drawings or as directed by the Engineer

## 1206.3 Piers and Abutments

Piers and abutments shall be in brick/stone masonry or plain/reinforced concrete. Randon rubble or dry rubble stone masonry shall not be permitted for piers and abutments.For concrete piers, horizontal construction joints shall be avoided as far as possible, by pouring the entire required concrete in one operation. Where construction joints are unavoidable, they shall be treated in accordance with Section 800 of these Specifications or in accordance with special provisions as directed by the Engineer. No vertical construction joint shall be permitted.

Construction joints shall not be permitted in splash zones.

The work shall be strictly in accordance with the drawings or as directed by the Engineer.

In case of tall piers and abutments, use of slip form shall be preferred. The design, erection and raising of slipform shall be subject to special specifications which will be furnished by the Contractor. The concrete shall also be subject to additional specifications as necessary. All specifications and arrangements for use of slipform and placing of concrete therein shall be subject to the approval of the Engineer.

The top surface of foundation/well cap/pile cap over which new concrete is to be laid, shall be scraped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

In case of solid (non-spill through type) abutments and hollow concrete piers, weep holes as shown on the drawings or as directed by the Engineer, shall be provided in conformity with Clause 1206.6 of these Specifications.

The surface finish shall be smooth, except on the earth face of abutments which shall be rough finished.

In case of abutments likely to experience considerable movement on account of earth pressure from backfill of approaches and settlement of foundations, the construction of the abutment shall be followed by filling up of embankment in layers to the full height to allow for the anticipated movement during construction. Casting of superstructure resting on the abutment shall be taken up only thereafter.

The backfill behind solid abutments, wings and return walls shall conform to the specifications given in IRC:78. The filter material shall be well packed to a thickness of not less than 600 mm with smaller size towards the soil and bigger size towards the wall and provided over the entire surface behind abutments, wings or return walls to the full height.

Filter materials need not be provided in case of spill through type of abutments.

### 1206.4 Pier Cap and Abutment Cap

The locations and levels of pier cap, abutment cap, pedestals and bolts for fixing bearings, shall be checked carefully to ensure alignment in accordance with the drawings.

The surface of cap shall be finished smooth and shall have a slope for draining off water as shown on the drawings or as directed by the Engineer. For short span slab bridges with continuous support on pier caps, the surface shall be cast horizontal. The top surface of the pedestal on which bearings are to be placed shall also be cast horizontal.

The surface on which elastomeric bearings are to be placed shall be wood float finished to a level plane which shall not vary more than 1.5 mm from straight edge placed in any direction across the area. The surface on which other bearings (steel bearings, pot bearings) are to be placed shall be cast about 25 mm below the bottom level of bearings or as indicated on the drawings.

### 1206.5 Dirt wall, Return wall and Wing wall

In case of cantilever return walls, no construction joint shall be permitted. The dirt wall and cantilever return walls shall be cast in one operation.

For gravity type masonry and concrete return and wing wall, the surface of foundation shall be prepared in the same manner as that prescribed for construction of abutment. No horizontal construction joint shall be provided.

Vertical construction joint may be provided, if shown on the drawing or as directed by the Engineer.

Vertical expansion gap of 20 mm shall be provided in return wall / wing wall at every 10 metre intervals or as directed by the Engineer. The 20 mm gaps shall be filled with suitable type of asphaltic/bituminous board, so as to prevent embankment material from coming out. The cost of such board shall be borne by the Contractor and shall be incidental to the work.

For masonry/concrete return walls and wing walls, weep holes shall be provided as prescribed for abutments or as shown on the drawings.

The finish of the surface on the earth side shall be rough while that of the front face shall be smooth.

Coping for wing wall/return wall in brick masonry or stone masonry shall conform to Sections 600 and 700 of these Specifications.

### 1206.6 Weep Holes

Weep holes shall be provided on all plain concrete, reinforced concrete, brick and stone masonry structures such as, abutment, wing wall and return walls as shown on the drawings or as directed as by the Engineer to permit water to flow out without building up pressure in the back fill. Weep holes shall be provided with 100 mm diameter AC/PVC/HDPE pipe for structures in plain/reinforced concrete or brick masonry. In case of stone masonry, weep holes shall be of rectangular shape 80 mm wide, 150 mm high or circular with 150 mm diameter. Weep holes shall extend through the full width of concrete/masonry with slope of about 1 vertical: 20 horizontal towards the draining face. The spacing of weep holes shall be 1 m in either direction or as shown in the drawings with the lowest at 150 mm above the low water level or ground level whichever is higher or as directed by the Engineer.

### 1206.7 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed requirements.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

### 1206.8 Tolerances in Concrete Elements

| | | | |
|---|---|---|---|
| i) | Variation in cross-sectional dimensions | : | +10 mm, -5 mm |
| ii) | Misplacement from specified position in plan | : | 10 mm |
| iii) | Variation of levels at the top | : | ±10 mm |
| iv) | Variations of reduced levels of bearing areas | : | ± 5 mm |
| v) | Variations from plumb over full height | : | ±10 mm |
| vi) | Surface unevenness measured with 3 m straight edge All surfaces except bearing areas | : | 5 mm |
| | Bearing areas | : | 3 mm |

### 1206.9 Measurements for Payment

Masonry in substructure shall be measured in cubic metres in accordance with Sections 600 and 700 of these Specifications, based on the quantities ordered or as shown on the drawings.

Concrete in substructure shall be measured in cubic metres in accordance with Section 800 of these Specifications, based on the quantity ordered or as shown on the drawings. No deduction shall be made for weep holes.

Steel in concrete of substructures shall be measured in tonnes, in accordance with Section 1000 of these Specifications, based on the quantity ordered or as shown on the drawings.

Weep holes in concrete/brick masonry structure shall be measured in numbers. For structures in stone masonry, weep holes shall be deemed to be included in the item of stone masonry work and shall not be measured separately.

### 1206.10 Rate

The contract unit rates for masonry, concrete and reinforcement and structural steel shall include all works as given in respective Sections of these Specifications and cover all incidental items for furnishing and providing substructure as mentioned in these Specifications and shown on the drawings.

The contract unit rate for weep holes shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications

## 1207 RAFT FOUNDATIONS

### 1207.1 Description

The work shall cover furnishing and providing reinforced cement concrete raft foundation with attached reinforced concrete cutoff wall or plain cement concrete detached cut off walls with launching aprons on upstream and downstream side placed in open excavation in accordance with the drawings and these specifications or as directed by the Engineer.

### 1207.2 Workmanship

#### 1207.2.1 *Preparation of foundations*

Excavation for foundation shall be carried out in accordance with Section 300 of these Specifications. The excavation for cut off walls shall be done to accommodate leveling course of 100 mm thickness. Such extra excavation shall be done just before laying lean concrete below cut off walls. The excavation shall be made only to the exact depth as shown in the drawing. In the event of excavation having been made deeper than that shown in the drawing or as directed by the Engineer, the extra depth shall be made up by M10 Concrete. This shall be done at the cost of contractor and shall be considered as incidental to the work.

The concreting of cut off walls and the raft proper shall be done in dry condition and the contractor shall provide for adequate dewatering arrangements, whenever required, to the satisfaction of the Engineer.

Where light blasting is required to be done, though in rare cases to remove the local rock outcrops or other hard strata, the same shall be carried out in accordance with these specifications. Where blasting is likely to endanger adjacent foundations or other structures, controlled blasting with necessary precautions shall be resorted to. It would be necessary to remove all unwarranted hard strata (mostly local spots) while doing excavation before starting concreting of cut off walls.

#### 1207.2.2 *Setting out*

The plan dimension of the longitudinal and cross cut off walls shall be set out at the bottom of cut off walls and checked with respect to original reference line & axis. It shall be ensured that at no point the bottom of cut off is higher than the level indicated on the drawing or as directed by the Engineer.

#### 1207.2.3 *Construction*

i) Excavation for raft foundation shall be carried out in accordance with dimensions of structure with 300 mm extra on all sides. For guidance regarding safety precautions to be taken, IS:3764 may be referred.

ii) A layer of M10 concrete of 100 mm thickness shall be provided below cut off walls to provide even surface and to ensure proper quality of concrete. Before laying lean concrete, the soil surface shall be properly cleaned of all loose material and wetted if the surface is dry. Muddy surface due to overwetting shall be removed. Construction joint in lean concrete shall be avoided as far as possible.

iii) Necessary formwork shall be used for lean concrete layer.The levels of lean concrete layer shall be checked at an interval of 3 m centre to centre in each direction, subject to minimum of 9 levels on the surface.

iv) The concreting of RCC cut off walls shall be done by providing suitable designed formwork. Considering the large depth of cut off wall and small thickness, the concreting shall be done in layers to facilitate proper compaction. The top of cut off wall shall be finished to match with the top of raft in case of PCC detached cut off walls.

The concreting of attached RCC cut off wall shall be terminated at a suitable level below the haunch as directed by the Engineer. In case of RCC attached cut off walls, the top surface at the construction joint shall be kept suitably rough to have proper bond between old and new concrete.

The longitudinal and cross cutoff walls shall be cast monolithically.

v) The formwork of cut off walls shall be carefully removed. As the removal of formwork starts from one end, the filling of soil on both sides of cut off wall with adequate compaction shall be ensured. Whenever such filling is done by sand, flooding may be done to ensure compaction. Care shall be taken that the filling of trench after gradual removal of formwork is done in such manner that the cut off wall is subjected to earth pressure from both sides equally upto about 1.20 metre below the raft top level.

vi) The soil in between the cut off walls shall be removed carefully without damaging the cut off wall for a required depth and filled up by granular material for 0.90m depth and properly compacted by suitable methods. If the bed is sandy upto such a depth, then no excavation and refilling (except for a depth of raft slab plus a layer of lean concrete below raft) would be required. The existing sandy bed shall, however, be suitably compacted. The filling of soil/sand on outer sider of cut off walls shall also be done simultaneously.

vii) Lean concrete M10 for a thickness of 100 mm shall be provided over the compacted sand/granular layer to provide even surface to support raft slab. The locations of pressure relief holes between the piers and pier and abutment shall be marked and suitable asbestos/PVC pipes 100 mm φ shall be placed in position.

viii) The locations of piers of abutments shall be marked on the lean concrete to facilitate laying & binding reinforcement for raft slab. Anchor rods/pins connecting pier/abutment with the raft slab shall be provided at pier and abutment location. In case the piers are provided with nominal or designed reinforcement such extra anchor rods/pins may not be provided. In such cases, the reinforcement of piers/abutment shall be erected and tied to raft reinforcement. The entire reinforcement and other arrangements like pressure relief holes shall be checked for its correctness as per drawing and as ordered by the Engineer.

ix) Necessary formwork shall be provided for raft slab concrete. In case of PCC detached cut off walls, specific formwork is not necessary since the top of cut off walls match with raft top and the raft is required to be laid between the cut off walls.

x) The raft concrete shall be the designed Mix and shall be cast carefully with proper mix design, preparation, laying & compaction as per Section 800 of these Specifications.

xi) The concrete shall be cured for specified period as per Section 800 of these Specifications.

xii) Launching aprons on upstream & down stream shall be provided as shown in the drawing as per Section 1300 of these Specifications.

xiii) Concreting of raft shall be done in one stretch. However, in case of long rafts, the construction joints shall be provided at specified locations or as directed by the Engineer. Before laying concrete in raft lean concrete shall be cleaned of all loose material and lightly moistened.

xiv) In case the situation so arises as to terminate the work of raft due to monsoon, extra cross cut off wall shall be provided at that section by the contractor as incidental to work. Such cross cut off wall is necessary to protect the part raft already cast.

xv) The top surface of raft shall be properly finished at designed level.

xvi) It shall be ensured that the pressure relief holes provided in raft slab are fully functional.

xvii) Normally, raft foundation including cut off walls shall be laid dry. Where dewatering is necessary for laying of concrete, it shall be carried out adopting any one of the following methods or any other method, approved by the Engineer:

a) By digging a pit or trench of suitable size, deeper than the founding level as necessary, beyond the foundation excavation so that the water flows into it and the excavated surface at founding level is fully drained.

b) By depressing water table by well point system or other methods.

c) By providing steel/concrete caissons or sheet piling for creating an enclosure for the foundations, which can subsequently be dewatered.

No pumping of water shall be permitted from the time of placing of concrete up to 24 hours after placement.

xviii) The concrete surface shall be finished smooth with a trowel. The location of construction joint and its treatment shall be done as per requirements of Section 800 of these Specifications. Formwork shall not be removed earlier than 24 hours after placing of concrete. Where formwork has been provided for top surface, the same shall be removed as soon as concrete has hardened. Curing of concrete shall be carried out by wetting of formwork before removal. After its removal, curing shall be done by laying not less than 100 mm thickness of loose moistened sand free from clods or gravel, over the concrete. The sand shall be kept continuously moist for a period of 7 days. Before backfilling is commenced, the loose sand shall be removed and disposed of as directed by the Engineer.

xix) All spaces excavated and not occupied by the foundations or other permanent works shall be refilled with earth up to surface of surrounding ground with sufficient allowance for settlement. All backfill shall be thoroughly compacted and in general, its top surface shall be nearly graded.

xx) Protective works, shall be completed before the onset of floods so as to avoid the risk of the foundation getting undermined.

xxi) It shall be ensured that the raft slab rests completely on the flexible foundation. Outcrops of rock if any shall be removed, so that the raft slab does not come in contact with this hard localized spots.

### 1207.3 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the criteria prescribed in Section 2000.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

### 1207.4 Tolerances

i) Variation in dimensions : +50 mm, -10 mm
ii) Misplacement from specified position in plan : 15 mm
iii) Surface unevenness measured with 3 m straight edge : 5 mm
(iv) Variation of levels at the top : ± 25 mm

### 1207.5 Measurement for Payment

Excavation in foundation shall be measured in cubic metres in accordance with Section 300 of these Specifications, based on the quantity ordered or as shown on the drawing.

Lean concrete shall be measured in cubic metres in accordance with Section 800 of these Specifications, based on the quantity ordered or as shown on the drawing.

Concrete in foundation shall be measured in cubic metres in accordance with Section 800 of these Specifications, based on the quantity ordered or as shown on the drawing.

Reinforcement steel shall be measured in tonnes in accordance with Section 1000 of these Specifications, based on the quantity ordered or as shown on the drawing.

### 1207.6 Rate

The contract unit rates for excavation in foundation, lean concrete, including dewatering and blasting where required, concrete in foundation and reinforcement steel shall include all works as given in respective Sections of these Specifications and cover all incidental items for furnishing and providing open foundation as mentioned in this Section and as shown on the drawings.

## Annexure – 1200/I-1

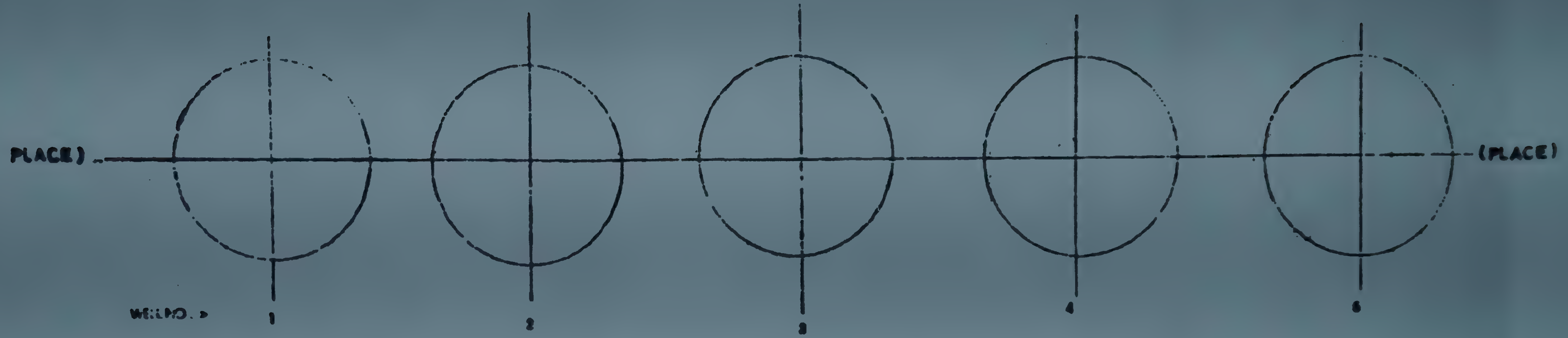
### HISTORY OF SINKING OF WELL NO ------------------------------

LOWEST BED LEVEL ___________ LOWEST WATER LEVEL _______ HIGHEST FLOOD LEVEL ______________ FOUNDING LEVEL _____________

HEIGHT OF CURB _____________ HEIGHT OF CUTTING EDGE _______

| DATE | STEINING | | | | | SINKING | | | | | DEPTH OF SUMP BELOW CUTTING EDGE | STRATA MET WITH | KENTLEDGE | | | QUANTITY OF DREDGED MATERIAL | REPORT REGARDING OBSTACLES OR SAND BELOW DURING SINKING | REPORT ANY SPECIAL METHOD OF SINKING EMPLOYED | REMARKS | SIGNATURE OF SUPERVISING OFFICER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | REDUCED LEVEL (RL) OF BOTTOM OF CUTTING EDGE | RL OF TOP OF STEINING BEFORE CASTING | RL OF TOP OF STEINING AFTER CASTING | HEIGHT OF STEINING CAST (COL.4-COL.3) METRE | TOTAL HEIGHT OF STEINING (INCLUDING) CURB AND CUTTING EDGE-(COL.4-COL.3) METRE | RL OF REFERENCE LEVEL (AT WHICH CUTTING EDGE IS PLACED) | INITIAL GAUGE READING METRE | FINAL GAUGE READING METRE | SINKING DURING THE DAY (COL.9-COL.8) METRE | RL OF BOTTOM OF CUTTING EDGE (COL.7-COL.8) METRE | METRE | | WEIGHT TONNES | ECCENTRICITY ALONG X-AXIS METRE | ECCENTRICITY ALONG Y-AXIS METRE | CUBIC METRE | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | | | | | | | | | | | | | | | | | | | | |

## Annexure – 1200/I-2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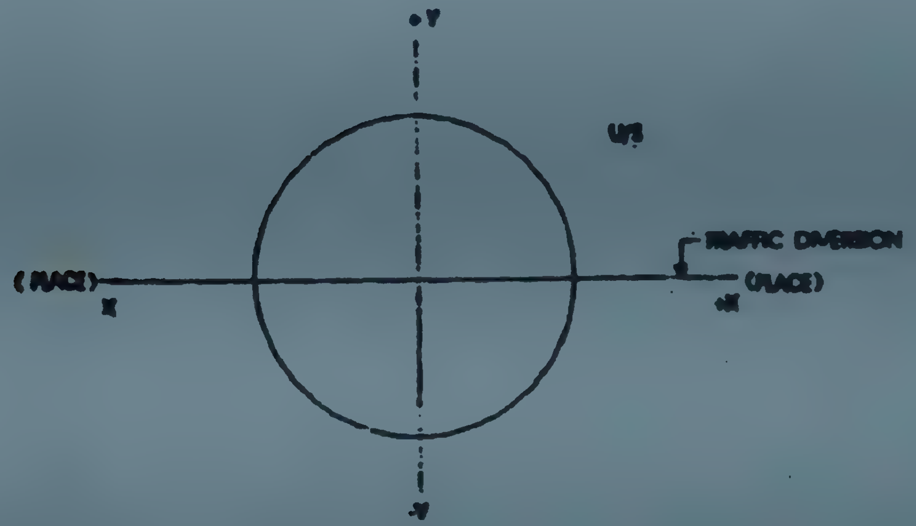
PLAN SHOWING WELL NOS.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-Y

PLAN OF WELL NO.....

## Annexure 1200/II

## (Refer Clause 1208.10)

**TILT AND SHIFT IN WELL NO:-**

| DATE | TOTAL STEINING METRE | TOTAL SINKING METRE | REDUCED LEVELS (R.L'S) OF GAUGE MARKS | | | | | | TILT ALONG X-AXIS COLUMN 6 DIVIDED BY WELL DIA | TILT ALONG Y-AXIS COLUMN 9 DIVIDED BY WELL DIA | RESULTANT TILT $\sqrt{(\text{COL. }10^2+\text{COL. }11^2)}$ | SHIFT | | | ACTION TAKEN FOR RECTIFICATION | REMARKS | SIGNATURE OF SUPERVISING OFFICER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ALONG X-AXIS | | | ALONG Y - AXIS | | | | | | | | | | | | |
| | | | (PLACE) END | (PLACE) END | DIFFERENCE (COL.5 - COL.4) METRE | (U/S) | (D/S) | DIFFERENCE (COL.8 - COL.7) METRES | | | | ALONG X-AXIS WITH DIRECTION METRE | ALONG Y-AXIS WITH DIRECTION METRE | RESULTANT $\sqrt{S}$ (COL. 13)$^2$ + [(COL. 14)$^2$]½ METRE | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | . | | | |
| | | | | | | | | | | | | | | | | | | |

# MAP

# 1300

# PROTECTION WORKS AND DRAINAGE

# 1301 APRON

## 1301.1 Scope

This work shall consist of laying boulders of the required size directly or in wire crates where the required size stones are not available, on the bed of rivers or streams, nallahs, etc. for protection against scour beyond curtain wall and shall be 600 mm thick unless otherwise specified on the drawings or as directed by the Engineer.

## 1301.2 General

**1301.2.1** Where the boulders of the required size are not available, economically cement concrete blocks with M15 nominal mix or stone in wire crates shall be used in place of isolated stones of equivalent weight.

**1301.2.2** The stones used in apron shall be sound, hard, durable and fairly regular in shape weighing not less than 40 kg each. Stone subject to marked deterioration by water or weather shall not be used.

**1301.2.3** The surface on which the apron is to be laid shall be levelled and prepared for the length and width as shown on the drawings. In case the surface on which apron is to be laid is below the low water level, the ground level may be raised upto low water level by dumping earth, moorum, boulders or stones or brick bats and the apron laid thereon. The quantity of stone required in the apron shall be reworked out by taking the toe of pitching at higher level.

**1301.2.4** Flexible Apron shall be provided beyond curtain walls for a minimum distance of 3 m on upstream side and 6 m on down stream side unless otherwise specified on the drawing or as directed by the Engineer. Generally, the length of apron shall not be less than two times the depth of the curtain wall.

**1301.2.5** The work of floor protection, like flooring, cut-off walls and apron shall be completed along with foundations of C.D. work/bridge and well before the on set of monsoon. The superstructure of bridge shall be done only on completing floor protection works.

## 1301.3 Laying Boulder Apron

**1301.3.1** The size and weight of stone should conform to **Table 1300.1** below. In no case shall any fragment weigh less than 40 kg. The specific gravity of stones shall be as high as possible and it shall not be less than 2.65.

**Table 1300.1**

| Mean Design Velocity m/sec. | Minimum Size and Weight of Stone | |
|---|---|---|
| | Diameter (mm) | Weight (kg) |
| upto 2.5 | 300 | 40 |
| 3.0 | 380 | 76 |
| 3.5 | 510 | 184 |
| 4.0 | 670 | 417 |

**1301.3.2** To ensure regular and orderly disposition of the full intended quantity of stone in the apron, template crosswalls in dry masonry shall be built about a meter thick and to the full height of the specified thickness of the apron at intervals of 30 m all along the length and width of the apron. Within these walls, the stone then shall be hand-packed.

### 1301.4 Laying Wire Crates and Mattresses in the Apron

**1301.4.1** Wire Crates shall be made from hot dipped galvanized mild steel wire of diameter not less than 4 mm in annealed condition conforming to IS:280. The galvanizing coating shall be heavy coating for soft condition conforming to IS:4826.

**1301.4.2** The mesh of the crate shall not be more than 150 mm.

**1301.4.3** Wire crates built in-situ, shall not be larger than 7.5 m x 3 m x 0.6 m, nor smaller than 2 m x 1 m x 0.3 m. Sides of large crates shall be securely stayed at intervals of not more than 1.5 m to prevent bulging.

**1301.4.4** For deep or inaccessible situations, wire crates can be made smaller size of 2 m x 1 m x 0.3 m.

**1301.4.5** The netting shall be made by fixing a row of spikes on a beam at a spacing equal to the mesh. The beam must be a little longer than the width of netting required. The wire is to be cut to lengths about three times the length of the net required. Each piece shall be bent at the middle around one of the spikes and the weaving commenced from one corner.

**1301.4.6** A double twist shall be given at each intersection. This twisting shall be carefully done by means of a strong iron bar, five and half turns being given to the bar at each splice.

**1301.4.7** The bottom and two ends of the crate or mattresses shall be made at one time. The other two sides shall be made separately and shall be secured to the bottom and the ends by twisting adjacent wires together. The top shall be made separately and shall be fixed in the same manner as the sides after the crates or mattress have been filled.

**1301.4.8** Wherever possible, crates shall be placed in position before filling with boulders. The crates shall be filled by carefully hand packing the boulders as tightly as possible and not by merely throwing in stones or boulders.

## 1302 PITCHING ON SLOPES

### 1302.1 Scope

The work shall consist of covering the slopes of guide banks/walls, training works and road embankment with stones, boulders or bricks over a layer of granular material called filter.

### 1302.2 Pitching

**1302.2.1** The thickness of pitching shall be minimum 225 mm or as indicated on the drawings. The stone shall be sound, hard and fairly regular in shape.

**1302.2.2** Quarry stone shall be used. Round boulders shall not be allowed. The stone subject to marked deterioration by water or weather shall not be accepted. No stone, weighing less than 25 kg shall be used. The size and weight of stones shall be as given in **Table 1300.2**. The sizes of spalls shall be minimum 25 mm and shall be suitable to fill the voids in the pitching.

**1302.2.3** Where the required size stones are not economically available, cement concrete blocks in M15 grade or stones in wire crates may be used in place of isolated stones of equivalent weight.

**Table 1300.2 Minimum Size and Weight of Stone**

| Mean Design Velocity m/sec. | Minimum Size and Weight of Stone | | | |
|---|---|---|---|---|
| | For Pitching Slope 2 :1 | | For Pitching Slope 3:1 | |
| | Diameter (mm) | Weight (kg) | Diameter (mm) | Weight (kg) |
| Upto 2.0 | 220 | 25 | 220 | 25 |
| 2.5 | 300 | 40 | 300 | 40 |
| 3.0 | 300 | 40 | 300 | 40 |
| 3.5 | 350 | 59 | 300 | 40 |
| 4.0 | 450 | 126 | 350 | 59 |

## 1302.3 Filter Media

**1302.3.1** To drain off the seepage water and to prevent erosion of the base material, one or more layers of graded materials, commonly known as a filter medium, shall be provided underneath the pitching. The material for the filter shall consist of sand gravel, stone or coarse sand.

The gradation of the filter material shall satisfy the following requirements :

i) $$\frac{D_{15} \text{ of filter}}{D_{85} \text{ of base material}} < 5$$

ii) $$4 > \frac{D_{15} \text{ of filter}}{D_{15} \text{ of base material}} < 20$$

iii) $$\frac{D_{50} \text{ of filter material}}{D_{50} \text{ of base material}} < 25$$

iv) The grain size curve of the filter should be roughly parallel to that of the base material.

***Notes :*** 1) Filter design may not be required if embankment consists of CH soil or CH soils with liquid limit greater than 30 which are resistant to surface erosion. In this case, if a layer of material is used as bedding for pitching, it shall be well graded and its $D_{85}$ size shall be at least twice the maximum void size in pitching.

2) In the foregoing $D_{15}$ means the size of that sieve which allows 15 percent by weight of the filter material to pass through it and similar is the meaning of $D_{50}$ and $D_{85}$.

3) The filter shall be compacted to a firm condition.

**1302.3.2** The thickness of filter may generally be 150 mm unless otherwise shown on the drawing or as directed by the Engineer.

### 1302.4 Construction Operations

**1302.4.1** Before laying the pitching, the sides of banks shall be trimmed to the required slope and profile put up by means of line and pegs at intervals of 3 m to ensure regular straight work and a uniform slope throughout. Depressions shall be filled and thoroughly compacted.

**1302.4.2** The filter granular material shall be laid over the prepared base and compacted to the thickness specified on the drawings.

**1302.4.3** The lowest course of pitching shall be started from the toe wall and built-up in courses upwards. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Section 700 in case of dry rubble pitching and shall be in brick wall in cement mortar 1:4 in case of brick pitching conforming to Section 600 of these Specifications.

**1302.4.4** The stone pitching shall commence in a trench below the toe of the slope. Stone shall be placed by derrick or by hand to the required length, thickness and depth conforming to the drawings. Stones shall be set normal to the slope, and placed so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of pitching. The largest stones shall be placed in the bottom courses and for use as headers for subsequent courses.

**1302.4.5** When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices between adjacent stones shall be filled in with spalls of the proper size and wedged in with hammers to ensure tight packing.

**1302.4.6** When two or more layers of stones are to be laid to obtain the design thickness of pitching, dry masonry shall be used and stones shall be well bonded. To ensure regular and orderly disposition of the full intended quantity of stone as shown, template crosswalls in dry masonry shall be built about a metre wide and to the full height of the specified thickness at 10 m intervals and all along the length and width of the pitching. Within these walls, the stones shall be hand packed as specified.

**1302.4.7** Where bricks are to be used, the same shall be laid on the prepared based in one or more layers as specified. When more than one layer is to be adopted, adjacent layers shall be properly bonded by means of a sufficient number of pin headers, extending from one layer to the other. The bond used in laying shall be as directed by the Engineer.

### 1302.5 Toe Protection

**1302.5.1** This work shall consist of constructing a toe wall, retaining/breast wall or close bamboo walling at the junction of embankment slope and general ground level to protect the embankment from damages.

**1302.5.2** Where embankment is provided with slope pitching conforming to Clause 1302.2 and launching apron conforming to Clause 1301 of these Specifications, toe wall shall be provided at the junction of slope pitching and launching apron so as to protect the slope pitching from falling. The toe wall shall be in dry rubble masonry conforming to Section 700 of these Specifications.

**1302.5.3** Retaining wall/breast wall as toe protection shall be conforming to Section 1600 of these Specifications.

**1302.5.4** Close bamboo walling shall consist of bamboo, eucalyptus, sal or other locally available bullahs/ballies having 65 mm to 75 mm diameter. The required diameter of bullahs/ballies of bamboo shall be checked at a distance of 1.2 m from the wider end of the diameter of the bamboo/bullah. The bullahs/ballies shall be painted with coal tar in the entire length.

The length of bamboo bullah/ballies shall preferably be not less than 1.2 m and not more than 3 m and these shall be driven about the half length in the ground at close interval of 150 mm c/c. The bamboo bullah/ballies, thus driven in the ground shall have minimum of three stout horizontal half split bamboo runner/stays at equal spacing. The horizontal stays/runners shall be adequately fixed with nails.

The exposed surface of bamboo walling shall be lined with sheets made from cut drums properly fixed with nails.

The bullahs shall be fitted with iron cap on wider diameter ring to facilitate their driving. The bullah should be placed and hoisted at the required position and driven with the help of iron monkey weighing 800 kg to 1000 kg attached with a jute or steel rope and moving through a guiding rod. The rope shall be passing through a pulley fitted at the top of the tripod stand and hammering done by pulling and releasing the rope manually. After completion of driving of the bullah/balli, the iron cap shall be removed.

## 1303 RUBBLE STONE/BRICK FLOORING OVER CEMENT CONCRETE BEDDING

### 1303.1 Scope

This work shall consist of constructing rubble stone/brick flooring in cement mortar laid over a cement concrete bedding. The rigid flooring shall be provided under the bridges and culverts and extend for a distance of at least 1.5 m on upstream side and 3 m on downstream side unless otherwise specified on the drawings or as directed by the Engineer.

### 1303.2 Construction Operations

**1303.2.1** Excavation for laying foundation of bed protection shall be carried out as per these Specifications under the supervision of the Engineer. Before laying the concrete bedding, the excavated trench shall be thoroughly inspected by the Engineer to ensure :

a) There are no loose pockets, unfilled depressions left in the trench

b) The soil at the founding level is properly compacted to the line and level

c) All concrete and other elements are laid in the dry bed.

**1303.2.2** 150 mm thick cement concrete M10 grade shall then be laid in accordance with provisions of Section 800 of these Specifications. The surface of the concrete shall not be given a smooth finish. The paving work shall be embedded in green concrete.

**1303.2.3** Where rubble stone is specified as flooring, it shall be done with flat stones 150 mm thick. The stones shall be bedded on a 25 mm thick layer of cement mortar 1:5. Spalls shall be used to fill the voids. The joints shall then be filled with 1:3 cement mortar and finished neat. The stone shall break joints and the joints shall not exceed 20 mm in thickness.

**1303.2.4** Where bricks are to be used, the flooring shall be done with 150 mm thick brick on edge. Each layer of brick shall be bedded on 25 mm thick 1:5 cement mortar and the joints filled in with 1:3 cement mortar. The joints shall not exceed 10 mm in thickness.

**1303.2.5** The top of the flooring shall be kept 300 mm below the lowest bed level. The flooring shall extend upto the line connecting the end of splayed wing walls on either side of the bridge/culvert.

### 1303.3 Dry Rubble/Brick Flooring

**1303.3.1** This work shall consist of constructing dry rubble stone/brick flooring at cross-drainage works where the flow is insignificant (less than 1.5 m/sec) and no significant scour is expected.

**1303.3.2** The base for the flooring shall be prepared to the levels and slopes shown on drawing and compacted with hand rammers or other means to have an even bedding.

**1303.3.3** Where rubble stone is specified, the minimum thickness of flooring shall be 150 mm and made with one flat stone only. The stones shall be laid closely breaking joints and all joints shall be filled with spalls of the proper size and wedged in with rammers to ensure tight packing.

**1303.3.4** Where brick is the material to be used, the same shall be laid closely on the prepared base in one or more layers as shown on drawing and the bond used shall be as directed by the Engineer.

**1303.3.5** The top of the flooring shall be kept 300 mm below the lowest bed level.

## 1304 CURTAIN WALL

The flooring shall be enclosed by curtain walls in Cement Concrete M10 grade or stone/brick masonry in cement mortar 1:4 and taken to a depth of at least 1.5 m on the u/s side and 2 m on d/s side below the floor level. The flooring shall be continued over the top width of curtain wall. The depth of curtain wall shall not be less than normal scour depth.

## 1305 CHUTE DRAINS

### 1305.1 Scope

The work shall consist of providing chute drains across the embankment slopes in approaches of bridges and on horizontal curves connected at the toe of the embankment with parallel open drains discharging into a nearby nallah or cross drainage work as shown on the drawings or as directed by the Engineer.

### 1305.2 Materials

The materials for chute drain/open drain at toe of embankment shall comprise as under :

i) Brick masonry conforming to Section 600 of these Specifications.

ii) Coursed Rubble Stone masonry conforming to Section 700 of these Specifications.

iii) Plain Cement Concrete (M15 grade) conforming to Section 800 of these Specifications.

**1305.3** Chute drains shall be provided in sections of road in embankment (embankment height more than 8 m) at minimum 10 m intervals.

**1305.4** The sections of the road where chute drains are provided shall have prescribed camber on carriageway and shoulders. Concrete kerb and channel in such sections are provided to guide the road surface discharge through chute drains.

**1305.5** Chute drains of rectangular or trapezoidal sections may be adopted. For guidance reference may be made to IRC:SP:42 “Guidelines on Road Drainage”.

**1305.6** For hydraulic design of chute drains or open toe drain, IRC:SP:42 “Guidelines on Road Drainage” may be referred.

**1305.7** The open drain at the toe of embankment shall be located as far as possible away from the imaginary slope line of 4H : IV or alternatively the open drain is lined with stone/brick masonry or concrete.

## 1306 ROADSIDE DRAINS

The side drains shall be constructed in accordance with the requirements of Section 300 of these Specifications, to the lines, grades, dimensions and other particulars shown on the drawings.

The schedule of work shall be so arranged that the drains are completed in proper sequence with the road works to ensure that no excavation of the completed road works is necessary subsequently or any damage is caused to these works due to lack of drainage.

## 1307 HILLSIDE DRAINS

The hillside drains shall be constructed in accordance with the requirements of Section 1600 of these Specifications, to the lines, grades, dimensions and other particulars shown on the drawings.

## 1308 CATCH WATER/INTERCEPTING DRAINS

Catch Water/Intercepting drains shall be provided on hill slopes to intercept water flowing from upper reaches and guide such flow into culverts. These shall be of trapezoidal shape and lined. The drains shall be constructed in accordance with the requirements of Section 1600 of these Specifications, true to the specified lines, grades, levels and dimensions as shown on the drawings.

## 1309 MEASUREMENTS FOR PAYMENT

**1309.1** The protection works shall be measured as setforth below. If directed by the Engineer for measurement, the materials may have to be stacked at site before laying and nothing extra will be paid to the Contractor for this stacking.

**1309.2** Preparation of the base and earthwork in excavation for protection works shall be incidental to the work and shall not be measured separately.

**1309.3** The boulders and wire crates in apron shall be measured in cubic metres.

**1309.4** The filter and stone pitching shall be measured separately in cubic metres.

**1309.5** Bamboo/Eucalyptus/Sal Walling complete shall be measured in running linear metres.

**1309.6** Rubble stone/brick flooring and cement concrete bedding shall be measured in cubic metres for each class of material.

**1309.7** Dry stone/brick flooring shall be measured in square metres for one or two layers as shown on the drawings.

**1309.8** Curtain walls shall be measured in cubic metres.

**1309.9** Chute drains and open drains shall be measured in linear metres.

**1309.10** Surface drains shall be measured as per Section 300 of these Specifications.

**1309.11** Hillside drains shall be measured as per Section 1600 of these Specifications.

**1309.12** Catch-water/Intercepting drains shall be measured as per Section 1600 of these Specifications.

## 1310 RATE

**1310.1** The contract unit rate for 1 cum of finished work of apron shall include the cost of all material, labour, tools and plants for completing the work according to above Specifications.

**1310.2** The contract unit rate for 1 cum of filter or stone pitching on slopes shall include the cost of preparing the bases, putting to the profiles, laying and compacting the filter and stone pitching of dry rubble/brick revetment for embankment slopes to the specified thickness, lines, curves, slopes and levels and all labour and materials as well as tools and plant required for the work.

**1310.3** The contract unit rate for bamboo/bullah walling shall include the cost of all material, labour, tools, plants and incidentals for completing the work as per Specifications and as shown in the drawings.

**1310.4** The contract unit rate for rubble stone/brick flooring shall include the cost of all material, labour and tools and plant for completing the work as per the above specifications and as shown on the drawings.

**1310.5** The contract unit rate for concrete in footing of curtain walls shall include cost of all materials, labour, tools and plants for completing the work as per specifications and as shown on the drawings.

**1310.6** The contract unit rate for brick/stone masonry in cut off walls shall include cost of all materials, labour, tools and plants for completing the work as per specifications and as shown on the drawings.

**1310.7** The contract unit rate for chute drains and open drains shall include cost of all materials, labour, tools and plants for completing the work as per specifications and as shown on the drawings.

**1310.8** The contract unit rate for surface drains shall be as per provisions of Section 300 of these Specifications.

**1310.9** The contract unit rate for hillside drain shall be as per provisions of Section 1600 of these Specifications.

**1310.10** The contract unit rate for Catch-water/Intercepting drains shall be as per provisions of Section 1600 of these Specifications.

# 1400

# SUPERSTRUCTURE, BEARINGS, EXPANSION JOINTS, WEARING COAT AND APPURTENANCES FOR STRUCTURES

# 1401 SUPERSTRUCTURE

## 1401.1 Description

The work shall cover furnishing and providing of superstructure in accordance with the drawings and as per these Specifications or as directed by the Engineer.

## 1401.2 Materials

Materials shall conform to Section 2000 of these Specifications.

## 1403.3 General

**1401.3.1** For bridges having overall length of 30 m and above, a method statement for construction, indicating the following, shall be submitted by the Contractor for approval of the Engineer, well in advance of the commencement of the construction of superstructure.

i) Sources of Materials
ii) Design, erection and removal of formwork
iii) Production, transportation, laying and curing of concrete
iv) Prestressing system, if applicable
v) Personnel employed for execution and supervision
vi) Tests and sampling procedure
vii) Equipment details
viii) Quality Management System to be adopted including Quality Manual
ix) Safety measures
x) Any other relevant information

**1401.3.2** Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark so that the completed superstructure is in full accordance with the drawings and as approved by the Engineer.

**1401.3.3** The formwork, steel reinforcement, structural concrete and prestressing for concrete superstructure shall conform to Sections 800, 900, and 1000 respectively, of these Specifications.

**1401.3.4** Specifications with regard to some of the common types of concrete superstructure construction shall be as given in subsequent clauses of this Section.

## 1401.4 Reinforced Concrete Construction

### 1401.4.1 *Solid slabs*

Where adjacent span of slab has already been cast, the expansion joint and filler board shall be placed abutting the already cast span, which shall form the shutter on that side of the new span to be cast. The reinforcement for the road kerb and railings embedded in the slab shall be tied in position before casting of slab. The entire slab shall be cast in one go. Where the slab is continuous over two spans or more, the entire span of the first slab and the length of the slab in the next adjacent span up to the point of contraflexure, shall be cast in one go, the same sequence of concreting being repeated for additional spans as required. No other construction joint shall be allowed except with the express permission of the Engineer. In very wide slabs, however, longitudinal construction joints may be permitted with the approval of the Engineer. Construction joints, if provided, shall be made in the prescribed manner as per Section 800 of these Specifications.

The portions of solid slab near expansion joints shall be cast along with reinforcements and embedment for expansion joints. For this purpose, the portion of solid slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

Where wearing coat is required to be provided after the slab has been cast, the surface of the slab shall be finished rough, but true to lines and levels as shown on the drawings, before the concrete has hardened.

The top of the slab shall be covered with clean moist sand as soon as the surface has hardened. Curing shall be carried out as per Section 800 of these Specifications.

If bearings are provided for the solid slab, the same shall be placed in position in accordance with the drawings, before casting of slab.

### **1401.4.2** *RCC T-beam and slab*

Provision of construction joint shall conform to the drawings or as per directions of the Engineer. No construction joint shall be provided between the bottom bulb and the web. If not indicated on the drawing, construction joint may be provided at the junction of the web and the fillet between the web and the deck slab, with the approval of the Engineer.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened. Care shall be taken for setting of bearings as indicated on the drawings.

### **1401.4.3** *RCC box cell*

Box Cell shall be in cement concrete grade and type and grade of reinforcement shall be as specified on the drawings. The box section shall be constructed with a maximum of one construction joint located in the web below the fillet between the deck slab and web.

The concreting operation shall be carried out continuously upto the construction joint. The concrete surface at the joint of the box shall be brushed with a stiff brush after casting while the concrete is still fresh and it has slightly hardened.

Before new concrete is poured, the surface of the already cast concrete shall be prepared as under:-

a) For hardened concrete, the surface shall be thoroughly cleaned to remove debris and made rough.

b) For partially hardened concrete, the surface shall be treated by wire brush followed by air jet.

c) The old surface shall be soaked with water without leaving puddles immediately before starting concreting to prevent the absorption of water from newly poured concrete.

d) New concrete shall be thoroughly compacted in the region of the joint.

Concrete shall be produced in a power driven mechanical mixer of capacity not less than 200 litres. A second mixer may also be used for continuous concreting where required.

Proper compaction of concrete shall be ensured by the use of screed or form vibrators for concrete in top slab of the box. For webs, needle vibrators of appropriate specifications shall be used to ensure proper compaction.

Cut–off walls and protective apron shall be as shown in drawing and according to Section 1300 of these Specifications. Plain cement concrete parapet (400 mm thick) shall be provided.

Top of the RCC raft (i.e., bottom of the box cell) shall be kept 300 mm below the lowest bed level.

### 1401.5 Prestressed Concrete Construction

#### 1401.5.1 *PSC girder and composite RCC slab*

PSC girder may be precast or cast in-situ as mentioned on the drawing or as directed by the Engineer. Girders may be post tensioned or pre-tensioned. Where precast construction is required to be adopted, selection of casting yard and details of methodology and equipment for shifting and launching of girders, shall be included in the method statement.

In case of cast in-situ construction, the sequence of construction including side shifting of girders, if required, and placing on bearings shall be in accordance with the drawings.

The PSC girder constituting the top flange, web and bottom flange shall be concreted in a single operation without any construction joint.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened.

Care shall be taken for correct alignment and setting of bearings as indicated on the drawings.

### 1401.5.2 *Box girder*

Box girders may be simply supported or continuous. Simply supported box girders shall have minimum construction joints as approved by the Engineer. In the case of continuous box girders, the sequence of construction and location of construction joints shall be strictly in accordance with the drawings.

The box section shall be constructed with only one construction joint located in the web below the fillet between the deck slab and the web.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened. Care shall be taken for setting of bearings as indicated on the drawings.

## 1401.6 Cast In-Place Voided Slabs

Voided slabs can be either in reinforced concrete or in prestressed concrete.

Voids can be either circular or rectangular in shape. Void formers may be manufactured from steel sheets, fibre reinforced cement, expanded polystyrene, HDPE, etc. They are generally corrugated to attain sufficient rigidity in order to prevent distortion or collapse during concreting. They should also be leak tight.

Void formers shall be suitably tied down in order to prevent flotation during concreting. Care shall be taken during placement of concrete to ensure that the concrete flows fully into the space beneath the void formers.

## 1401.7 Tolerances

### 1401.7.1 *Cast in-situ superstructure*

| | | | |
|---|---|---|---|
| a) | Variations in thickness of top and bottom slab for box girders, top and bottom flange for T-girders and slabs | : | -5 mm to +10 mm |
| b) | Variations in web thickness | : | -5 mm to +10 mm |
| c) | Variations in overall depth or width | : | -5 mm to +10 mm |
| d) | Variation in overall length and length between bearings | : | shall not exceed ± 10 mm or ± 0.1 percent of the span length, whichever is less |
| e) | Permissible surface unevenness in deck slab when measured with a 3 m straight edge or template | : | 5 mm |

### 1401.8 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

### 1401.9 Measurement for Payment

Concrete in superstructure shall be measured in accordance with Section 800, based on the quantity ordered or as shown on the drawings.

Steel reinforcement (untensioned) in superstructure shall be measured in accordance with Section 1000, based on the quantity ordered or as shown on the drawings.

High tensile steel (prestressing) in superstructure shall be measured in accordance with Section 1000, based on the quantity ordered or as shown on the drawings.

### 1401.10 Rate

The contract unit rates for concrete, steel reinforcement (untensioned) and high tensile steel (prestressing) shall include all works as given in respective Sections of these Specifications and cover all incidental items for furnishing and providing superstructure as mentioned in this Section and as shown on the drawings.

### 1401.11 Composite Type Construction

Composite type of superstructure for bridges comprising longitudinal steel girders with RCC solid slab as decking shall be provided for only simply supported bridges. All material for construction shall conform to Section 2000 of these Specifications.

Shear connectors between the steel girder and reinforced concrete deck shall be provided to ensure composite action of girders and RCC slab as shown on drawing or as directed by the Engineer.

No traffic shall be permitted on the bridge having composite type of superstructure prior to 28 days of concreting the deck for effective composite action. 150 mm x 150 mm haunches shall be provided between top of steel girder and soffit of slab. The sides of haunches shall be located outside a line drawn at 45° from the outside edge of the base of the connectors.

All structural steel components of the composite type superstructure shall be protected against corrosion by :

i) a minimum of three coats of paints, or

ii) a metal coating followed by two coats of paint.

The painting and protective coating shall be done in accordance with IS:1477 Code of Practice for Painting of Ferrous Metals in Buildings, and allied finishes.

### 1401.11.1 *Tolerances*

| | | | |
|---|---|---|---|
| a) | Variations in overall depth or width | : | ± 5 mm |
| b) | Variation in overall length | : | shall not exceed ± 10 mm between bearings mm or ± 0.1 percent of the span length, whichever is lesser |
| c) | Permissible surface irregularities when measured with a 3 m straight edge or template | : | 5 mm |

### 1401.11.2 *Tests and standards of acceptance*

The materials shall be tested in accordance with Section 2000 of Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed Standards of acceptance.

### 1401.11.3 *Measurements for payment*

Concrete in superstructure shall be measured in cubic metres in accordance with Section 800 of these Specifications based on the actual quantity used in work at site.

Steel reinforcement in superstructure shall be measured in accordance with Section 1000 of these Specifications based on the actual quantity used in work at site.

Structural steel in composite type superstructure shall be measured in tonnes on the net weight of steel beams computed on the basis of nominal weight of materials.

The weight of rolled beams shall be determined from the dimensions shown on the drawings taking unit weight as 78.4 kN per cum. Weight of protective coatings shall not be included. Steel in shear connectors shall be measured in tonnes as per Section 1000 of these Specifications.

### 1401.11.4 *Rate*

The contract unit rate for superstructure (composite type) shall include works, and all incidental items including furnishing, form work and providing as per Specifications and as shown in the drawings

## 1402 BEARINGS

### 1402.1 Description

This work shall consist of furnishing and fixing bearings in position in accordance with the details shown on the drawings, to the requirements of these Specifications or as directed by the Engineer.

### 1402.2 General

i) Bearing plates, bars, rockers, assemblies and other expansion or fixed devices shall be in accordance with the details shown on the drawings.

ii) The bearings may either be supplied directly to the Engineer by the manufacturer to be installed by the Contractor or supplied and installed by the Contractor as part of the contract. In the former case, the manufacturer shall be associated with the installation of the bearings to the full satisfaction of the Engineer, whereas in the latter case, the Contractor shall be solely responsible for the satisfactory supply and installation of the bearing. In the detailed description of the specification, a general reference shall be made to the Contractor or manufacturer and the interpretation shall be as per terms of contract.

iii) The Contractor shall exercise the utmost care in setting and fixing all bearings in their correct positions and ensuring that uniformity is obtained on all bearing surfaces.

iv) Bearings shall be handled with care and stored under cover.

v) When bearing assemblies or plates are shown on the drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade (not exceeding 12 mm) and shall be finished by grinding.

vi) It shall be ensured that the bearings are set truly level and in exact position as indicated on the drawings so as to have full and even bearing on the seats. Thin mortar pads (not exceeding 12 mm thickness) may be provided for this purpose.

vii) It shall be ensured that the bottoms of girders to be seated on the bearings are plane at the locations of the bearings and that the bearings are not displaced while placing the girders.

viii) MS bearings sliding on MS plates shall not be permitted. For sliding plate bearings, stainless steel surface sliding on stainless steel plate with mild steel matrix shall be used. The other option shall be to provide PTFE surface sliding on stainless steel.

ix) Segmental rollers are not permitted; only full cylindrical rollers shall be used. Adequate width of base plate shall be provided to cater for anticipated movements of the supporting structure.

x) For seismic Zones IV and V, roller and rocker bearing components shall have guides to prevent them from being displaced during earthquakes.

xi) For bridges with skew angle less than 20°, the bearings shall be placed at right angles to the longitudinal axis of the bridge. For bridges with skew angle greater than 20°, very wide bridges and curved bridges, the location of bearings shall be ensured as shown on the drawings.

xii) Easy access to the bearing shall be made available for purposes of inspection and maintenance. Provision shall also be made for jacking up of the superstructure so as to allow repair/replacement of bearings.

xiii) For types of bearings not covered in this Section, required specifications shall be as laid down in the contract.

## 1402.3 Steel Bearings

### 1402.3.1 *Materials*

### *1402.3.1.1 Mild steel*

Mild steel to be used for components of bearings shall comply with IS:2062, Steel for General Structural Purposes.

All components exceeding 50 mm in thickness requiring welding, the carbon content for such plates shall be ascertained and suitable welding procedure like pre-heating, use of low hydrogen electrodes etc, shall be adopted after approval by the Engineer.

### *1402.3.1.2 Forged steel*

Forged steel to be used in components of bearings shall be in accordance with Section 1000 of these Specifications.

All slabs shall be normalised after forging. If welding is involved and if the slabs are more than 20 mm thick, pre-heating of the slab up to 200°C shall be done.

### *1402.3.1.3 High tensile steel*

High tensile steel shall comply with IS:961.

### *1402.3.1.4 Cast steel*

Cast steel shall be in accordance with Sections 1000 and 2000 of these Specifications.

For the purpose of checking the soundness, castings shall be ultrasonically examined following procedures as per IS:7666, with acceptance standard as per IS:9565. The castings may also be checked by any other accepted method of non-destructive testing as specified in IS:1030.

Quality level of castings shall be Level 3 as per IS:9565.

### *1402.3.1.5 Construction operations*

a) All work of steel bearings shall conform strictly to the drawings and shall be in accordance with the provisions of this Section. Care shall be taken to ensure that all parts of an assembly fit accurately together. The workmanship shall satisfy all relevant provisions laid down in Section 1000 of these Specifications.

b) Knuckle pins, rolling surfaces of the rollers and bearing surface of the bearing plates shall be machined and all bolt holes shall be drilled. The whole bearings shall be fitted and finished as required for good quality machined work to the satisfaction of the Engineer. However, in case of bearings which are to be grouted or bedded on a suitable yielding material, any surface which is to be in permanent contact with the grout or the yielding material, may be left unmachined.

c) In prestressed concrete construction involving launching of girders slipping or jumping of rollers due to vibration or jolts, shall be avoided and adequate measures shall be taken to ensure that the roller assembly is not disturbed. It is normal practice to provide rocker bearings at the launching end and place the beam on the rocker slightly in advance of placing on the roller.

d) During concreting of girders, the bearings shall be held in position securely by providing temporary connection between the top and bottom plates in case of fixed bearings and between top plate, base plate and saddle plate in case of roller-cum-rocker bearings or by any other suitable arrangement which prevents the relative displacement of the components.

e) In precast prestressed girders, where recesses are left on the underside of girders to receive the anchor bolts, grout holes extending to the sides or top of the beam shall be provided. The grout hole shall be filled with cement sand grout of mix 1:1 or with grout made of non-shrink high strength mortar. Alternatively, the precast girder may be fitted with a template screwed or bolted into sleeves already cast in the concrete, which can be removed and replaced by the top plate of the bearing at the time of erection of superstructure.

### *1402.3.1.6 Workmanship*

a) Fabrication shall be carried out by an organization experienced and qualified to undertake precision engineering of this type as approved by the Engineer.

b) Workmanship shall be of good quality such as to achieve neat finish and good appearance.

c) Castings shall be true to the forms and dimensions shown on the drawings and shall be free from pouring faults, sponginess, cracks, blow holes and other defects, affecting their appearance or strength. Warped or distorted castings will not be accepted. Exposed surfaces shall be smooth and dense.

d) All castings shall be cleaned by sand or shot blasting to remove sand or scale and to present a clean uniform surface.

e) All irregularities, fins or risers shall be ground off flush with the adjacent surface. Castings with visible cracks, blow holes or similar blemishes shall be rejected if the imperfections are located in bearing surfaces or cannot be remedied to the satisfaction of the Engineer.

f) Imperfections which are not located in bearing surfaces shall be cleaned out, filled with weld metal of the appropriate composition and ground flush.

g) All surfaces of major components like top plates, saddle plates, base plates, rollers of the bearings shall be machined all over for correct alignment, interchangeability and proper fitting.

### 1402.3.1.7 *Tolerances*

Tolerances for individual components or of the assembled bearings shall be as shown on the drawings and subject to the approval of the Engineer.

Unless otherwise specified, the following tolerances shall be maintained.

i) **Rollers and Curved Surfaces**

Tolerances on diameter of rollers and all convex surfaces shall conform to K7 of IS:919.

Tolerances on diameter of all concave surfaces shall conform to D8 of IS:919.

ii) **Height of Bearings**

Tolerances on height of any component shall not exceed +0.5 mm. No minus tolerance shall be allowed. The edges of all ribs shall be parallel throughout their length.

iii) **Plates**

Tolerance on length and width of the plates shall not exceed +1.0 mm; tolerance on the thickness of the plate shall not exceed +0.5 mm. No minus tolerance shall be allowed. All rocking, rolling and sliding surfaces shall have a machine smooth finish to 20 micron maximum mean deviation as per IS:3073.

iv) **Castings**

No minus tolerance shall be allowed in the thickness of any part of the castings. The edges of all ribs shall be parallel throughout their length.

### 1402.3.1.8 *Installation of steel bearings*

i) General

a) Bearings shall be placed in the position as shown on the drawings with all bearing surfaces in full contact and to the tolerances as specified.

b) Roller and rocker bearings shall be placed so that their axes of rotations are horizontal and normal to the direction of movement of the members they support. Upper and lower bearing plates shall be set horizontal in both directions.

- c) During installation the bearings shall be pre-set with respect to the bearing axis to account for the movement due to the following :
  - i) Temperature variation between the average temperature prevailing at the time of installation and the mean design temperature.
  - ii) Shrinkage, creep and elastic shortening of prestressed girders.
- d) For bridges in gradient, the bearing plates shall be placed in a horizontal plane.

ii) Placing

- a) On supporting structures, pockets shall be provided to receive anchor bolts; one side of the pocket shall project beyond the bearing plate. The pocket shall be filled with mortar and the concrete bearing area also shall be finished level by a thin and stiff mortar pad (of thickness not exceeding 12 mm) just before placing of bearing assemblies or bottom plate on the concrete seat. The mortar shall be of mix 1:1 or of the non-shrink prepacked type.
- b) In case of precast girders, a recess of 6 mm shall be provided on the underside with a level finish for housing the bearing plate. A thin and stiff mortar pad with thickness not exceeding 3 mm, shall be provided over the top plate before lowering the precast beam in position in order to ensure full and even pressure on the plate surface.
- c) It shall be ensured that while placing the girders, the bearings are in their exact positions as indicated on the approved drawing and not displaced therefrom.
- d) All concrete surfaces to be in contact with the mortar shall be thoroughly cleaned and wetted for a period not less than 24 hours before placing mortar. Operations are to be carried out when the surface temperatures of the exposed bearings are the minimum practical.
- e) No mortar that is more than 30 minutes old after completion of mixing, shall be used.
- f) After placing and finishing the mortar, the bearing shall be checked for position and shims or other temporary supports removed and the mortar made good. If the bearing has moved, it shall be lifted, the mortar removed and the whole procedure repeated.
- g) Exposed faces of the mortar shall be cured under damp hessian for 7 days.

h) Placing of the bearing and mortar shall only be carried out in the presence of the Engineer.

iii) Checking, cleaning and lubrication: Before installation, each bearing shall be uncrated, dis-assembled and checked. Any damaged parts shall be made good for approval.

All bearings with sliding surfaces shall be cleaned and lightly lubricated with an approved lubricant immediately before installation.

*1402.3.1.9* *Testing*

i) Testing of bearings and all materials used in their manufacture shall be in accordance with IRC:83 (Part I).

ii) If required, a suitable number of complete bearings as specified by an accepting authority shall be tested to 1.25 times the design load. Recovery should be 100 percent. Contact surfaces shall be examined under lights for any defects, cracks, etc.

iii) For large lots, (consisting of 12 sets or more), the bearings manufacturer shall, unless otherwise directed by the Engineer, furnish a complete report on the process of quality control. The Engineer may appoint an authorized inspection agency for inspection on his behalf, which shall also submit reports to the Engineer regarding various tests performed on the bearing and certify the acceptance of the bearings. The quality control report shall cover the following:

a) A detailed system of quality control including stage by stage inspection, starting from raw materials up to the finished bearing.

b) Test certificates of all raw materials If manufacturer's test certificates are not available for the raw materials, the bearings manufacturer shall perform the necessary confirmatory tests as per relevant codes of practice and shall furnish the test results.

c) A list of consumption of raw material for a period of at least preceding one year.

d) Test certificates of bearings manufactured during preceding one year at the manufacturer's works.

iv) The Engineer shall reserve the right to witness inspection at manufacturer's works at any time. For this, the bearing manufacturer shall have in-house testing facilities as required.

v) In case the lot size of similar bearings exceeds 12 sets as per the direction of the Engineer, one extra bearing for each set of 24 bearings or part thereof, shall be manufactured and the cost of such extra bearing shall be borne by the user.

vi) The Engineer shall select the extra bearing(s) at random and shall perform various tests including destructive testing on it at his discretion, either at the manufacturer's works or at any other approved test laboratory, notwithstanding the test reports submitted.

vii) In case there is a major discrepancy regarding material, the Engineer shall declare the whole lot of bearings as unacceptable.

viii) In case minor defects in fabrication, like welding or machining, are found in the test bearing before destructive testing and if the test bearing is found to be acceptable after destructive testing, the minor defects in the test bearings shall not be a bar to the acceptance of the entire lot.

ix) The opinion of the Engineer in cases vii) and viii) shall be final and binding on the manufacturer.

#### *1402.3.1.11 Materials*

i) All materials, shall be original, unused or non-re-cycled conforming to relevant specifications.

ii) Cast Steel, Mild Steel, Stainless Steel shall conform to Section 2000 of these Specifications.

iii) Copolymer Poly Tetra Fluoro Ethylene (PTFE) unfilled quality shall have required properties as per BS:5400 and thickness as specified.

iv) Anchor Bolts shall be as per relevant IS specifications.

### 1402.4 Elastomeric Bearings

Elastomeric bearings shall cater for translation and/or rotation of the superstructure by elastic deformation.

#### **1402.4.1** *Materials*

i) Chloroprene Rubber (CR) only shall be used in the manufacture of bearings.

ii) Grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bayprene 110, Skyprene B-5 and Denka S-40V) shall be used.

iii) No reclaimed rubber or vulcanized wastes or natural rubber shall be used.

iv) The raw elastomer content of the compound shall not be lower than 60 percent by its weight. The ash content shall not exceed 5 percent. (as per tests conducted in accordance with ASTM D-297, Sub-Section 10).

v) Use of synthetic rubber-like materials such as Ethyl Propylene Dimonomer (EPDM), Isobutane Isoprene Copolymer (IIR) and Chloro-Isoprene Copolymer (CIIR) shall not be permitted.

### 1402.4.2 *Properties of elastomer*

The elastomer shall conform to the properties specified in **Table 1400.1**

**Table 1400.1 Properties of Elastomer**

| Property | Unit | Test Method, IS Specification Reference | Value of the Characteristic Specified |
|---|---|---|---|
| 1. Physical Properties | | | |
| 1.1. Hardness | IRHD | IS:3400 (Part II) | 60 ± 5 |
| 1.2. Minimum tensile strength | MPa | IS:3400 (Part I) | 17 |
| 1.3. Minimum elongation at break | Percent | IS:3400 (Part I) | 400 |
| 2. Maximum compression set (24h, 100 ± 1°C) | Percent | IS:3400 (Part X) | <35 |
| 3. Accelerated Ageing (72h, 100 ± 1°C) | | IS:3400 (Part IV) | (°C) |
| 3.1 Max change in hardness | IRHD | | +5 |
| 3.2 Max change in tensile strength | Percent | | ±15 |
| 3.3 Max change in elongation | Percent | | ±30 |
| 4. Maximum change from un-aged value | | | |
| 4.1 Shear modulus of the elastomer shall neither be less than 0.80 MPa nor greater than 1.20 MPa. | | | |
| 5. The adhesion strength of elastomer to steel plates determined according to IS:3400 (Part XIV) method A, shall not be less than 7 kN/m. | | | |

**1402.4.3** For elastomeric bearings (CR) used in adverse climatic conditions, the ozone resistance of elastomer shall be proved satisfactory when assessed by test according to IS:3400 (Part XX). On testing, the strain shall be 20 percent, the temperature shall be 40±1 degree Celsius, the duration shall be 96h and the ozone concentration shall be 50 pphm by volume.

Any cracking detected by visual observation at the end of the test shall be considered unsatisfactory. No specific tests for assessment of low temperature resistance are deemed necessary.

***Note:*** For use of elastomer in extreme cold climates, the Engineer may specify special grade of low temperature resistant elastomer in conformity with operating ambient temperature conditions. The specification of such special grade elastomer including the tests for low temperature resistance shall be as agreed by the Engineer with the producer/supplier.

**1402.4.4** Laminates of mild steel conforming to IS:226 shall only be permitted. Use of any other material like fibre glass or similar fabric as laminates shall not be permitted.

**1402.4.5** The manufacturers of elastomeric bearings shall satisfy the Engineer that they have in-house facilities for carrying out the following tests on elastomer in accordance with the relevant provisions of ASTM D-297.

| | | | |
|---|---|---|---|
| a) | Identification of polymers | : | to confirm the usage of Chloroprene (Appendix X-2) |
| b) | Ash content | : | to determine the percentage (Sub-Section 34) |
| c) | Specific gravity | : | (Sub-Section 15) |
| d) | Polymer content | : | (Sub-Section 10) |

The Engineer shall invariably get the test (a) performed in his presence or in the presence of his authorized representative. In case of any dispute regarding interpretation of results, the Engineer may carry out test as per ASTM S3452-78 (Chromatography test) at the manufacturer's cost in a recognized test house. The elastomer specimen to conduct the test shall be obtained from the bearing selected at random for destructive test. The remaining part of the test bearing shall be preserved by the Engineer for any test to be done later, if required.

### 1402.4.6 *Fabrication*

Bearing with steel laminates shall be cast as a single unit in a mould and vulcanised under heat and pressure.

Casting of elements in separate unit and subsequent bonding shall not be permitted. Cutting from large sized cast shall also not be permitted.

Bearings of similar size to be used in a particular bridge project shall be produced by identical process and in one lot as far as practicable. Phased production may be resorted to only when the total number of bearings is large.

The moulds used shall have standard surface finish adequate to produce bearings free from any surface blemishes.

Steel plates for laminates shall be sand blasted, clean of all mill scales and shall be free from all contaminants prior to bonding by vulcanization. Rusted plates with pitting shall not be used. All edges of plates shall be rounded.

Spacers used in mould to ensure cover and location of laminates shall be of maximum size and number practicable. Any hole at surface or in edge cover shall be filled in subsequently.

Care shall be taken to ensure uniform vulcanizing conditions and homogeneity of elastomer through the surface and body of bearings.

The bearings shall be fabricated with the tolerances specified in **Table 1400.2**.

**Table 1400.2 Tolerances**

| | Items | Tolerances |
|---|---|---|
| 1) | Overall plan dimensions | -0, + 6 mm |
| 2) | Total bearing thickness | -0, + 5 mm |
| 3) | Parallelism | |
| a) | of top surface of bearing with respect to the bottom surface as datum | 1 in 200 |
| b) | of one side surface with respect to the other as datum | 1 in 100 |
| 4)a) | Thickness of individual internal Layer of elastomer | + 20 percent (max. of 2 mm) |
| b) | Thickness of individual outer layer | -0, + 1 mm |
| 5) a) | Plan dimensions of laminates | - 3 mm, +0 |
| b) | Thickness of laminates | + 10 percent |
| c) | Parallelism of laminate with respect to bearing base as datum | 1 in 100 |

The vulcanizing equipment/press shall be such that between the platens of the press, the pressure and temperature are uniform and capable of being maintained at constant values as required for effecting a uniform vulcanization of the bearing.

The moulding dies utilized for manufacturing the bearings shall be so set inside the platen of the press that the pressure developed during vulcanization of the product is evenly distributed and the thickness maintained at all places are within acceptable tolerance limits taking into consideration the expansion/shrinkage allowance of vulcanizate (the product of vulcanization).

The raw compound which is introduced inside the metal dies for vulcanization shall be accurately weighed each time and shall be of sufficient quantity to ensure proper flow of material to every part of the die so that a homogeneous and compact bearing is produced without any sign of sponginess or deficiency of material at any place.

Before the rubber mix of any batch is used for producing vulcanized bearings, test pieces in the form of standard slab and buttons shall be prepared in accordance with prescribed standards and salient properties tested and recorded regularly against each batch of production to monitor the quality of the products.

### **1402.4.7** *Acceptance specifications*

The manufacturer shall have all the test facilities required for the process and acceptance control tests installed at his plant to the complete satisfaction of the Engineer. The test facilities and their operation shall be open to inspection by the Engineer on demand.

All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipment and labour shall be borne by the manufacturer unless otherwise specified or specially agreed to between the manufacturer and the Engineer.

A testing programme shall be submitted by the manufacturer to the Engineer and his approval obtained before commencement of acceptance testing.

Any acceptance testing delayed 180 days beyond the date of production shall require special approval of the Engineer and modified acceptance specification, if deemed necessary by him.

All acceptance testing shall be conducted by the Inspector with the aid of the manufacturer's personnel having adequate expertise and experience in rubber testing, working under the supervision of the Inspector and to his complete satisfaction.

Inspection and acceptance shall be carried out lot by lot.

#### *1402.4.7.1 Acceptance lot*

A lot under acceptance shall comprise all bearings, including the pair of extra test bearings where applicable, of equal or near equal size produced under identical conditions of manufacture, to be supplied for a particular project.

The size and composition of acceptance lot shall be got approved by the Engineer.

For the purpose of grading levels of acceptance, a lot size of 24 or larger number of bearings shall be defined as a large lot while a lot size of less than 24 number of bearings shall be defined as a small lot.

When the number of bearings of equal or near equal size for a single bridge project is large and phased production and acceptance is permitted, the number of bearings supplied in any single phase of supply shall comprise a lot under acceptance. When such phased supply is made, each such lot shall be considered as a large lot for the purpose of acceptance testing.

#### *1402.4.7.2 Levels of acceptance testing*

The following two Levels of acceptance testing shall be adopted, depending on lot size :

Level 1 acceptance testing is a higher level of inspection and testing and shall be applicable to large lots only, unless otherwise specified. This shall involve manufacture of two extra bearings for each lot to be used as test bearings and eventually consumed in destructive testing.

Level 2 acceptance testing shall be applicable to small lots only, for which one extra bearing shall be manufactured and shall not involve destructive testing of finished bearing. Out of the lot, one bearing shall be selected at random for carrying out material tests. This bearing shall be excluded from the lot accepted.

Acceptance testing Level 1 may be specified for small lots also at the sole discretion of the Engineer taking into account the special importance of a bridge project. The cost of extra bearings, in such cases shall be borne by the user, while the cost of all other materials, equipment and testing shall be borne by manufacturer.

### **1402.4.8** *Testing*

Acceptance testing shall comprise general inspection, test on specially moulded test pieces and test on complete bearings or sections for measurement of various quality characteristics detailed below :

### *1402.4.8.1 Acceptance testing Level 1*

i) General Inspection

a) All bearing of the lot shall be visually inspected for any defects in surface finish, shape or any other discernible superficial defects.

b) All bearings of the lot shall be checked for tolerances specified in **Table 1400.2**.

c) All bearings of the lot shall be subjected to axial load to correspond to óm (i.e. average compressive stress) = 15 MPa applied in steps and held constant while visual examination is made to check for discernible defects like :

- Misalignment of reinforcing plates
- Poor bond at laminate/steel interface
- Variation in thickness of elastomer layers
- Any surface defects
- Low stiffness

d) Deflection under loads between 30 percent and 100 percent of the maximum load for the application shall be measured and recorded for all bearings with sufficient accuracy (± 5 percent), Variation in stiffness of any individual bearing from the mean of the measured values for all such bearings of the lot shall not be larger than 20 percent (of the mean value).

ii) Tests on specially moulded test pieces

a) Test pieces shall be moulded by the manufacturer with identical compound and under identical vulcanising conditions as used in the manufacture of the bearings of the acceptance lot. The process shall be open to inspection by the Engineer.

b) Test pieces offered for inspection shall be identified by suitable markings and duly certified by the manufacturer.

c) The quality characteristics to be tested are listed below. The specification reference in parenthesis shall define the corresponding specification for test piece, test method and criterion for acceptance.

Composition (see Note 1 below)
Hardness (Table 1400.1, 1.1)
Tensile strength (Table 1400.1, 1.2)
Elongation at Break (Table 1400.1, 1.3)
Compression Set (Table 1400.1, 2)
Accelerated Ageing (Clause 1400.4, 2)
Adhesion Strength (Clause 1400.4, 2)
Ozone Resistance (see Note 2 below)

***Note 1.***

For acceptance testing, the properties and specific gravity of elastomer of test pieces from test bearing shall be compared with those for corresponding specially moulded test pieces furnished by the manufacturer. The following variations shall be deemed maximum acceptable :

| | |
|---|---|
| Specific Gravity | ± 02. |
| Ash Content | ± 0.5 percent |
| Hardness | (Table 1400.1, 1.1) |
| Tensile strength | (Table 1400.1, 1.2) |
| Elongation at Break | (Table 1400.1, 1.3) |
| Compression Set | (Table 1400.1, 2) |
| Accelerated Ageing | (Table 1400.1, 3) |
| Adhesion Strength | (Clause 1402.4.2) |

***Note 2.***

Ozone resistance test can be waived by the Engineer for bearings of CR when satisfactory results of ozone resistance tests on similar grade of elastomer may be available from process control records or development test data furnished by the manufacturer.

Where such process control data are not available or the frequency of testing not deemed adequate, ozone resistance test shall be mandatory for acceptance of bearings of CR.

However, such tests may not be insisted upon for bearings not located in adverse conditions of exposure and where the test on accelerated ageing could be considered as adequate.

Process and acceptance control tests for ozone resistance by an independent testing agency shall be acceptable.

iii) Tests on complete bearings or sections

1) Two bearings shall be selected at random from the lot as test bearings. These bearings shall be excluded from the lot accepted.

2) Tests for determination of the following properties shall be conducted on test bearings :

shear modulus

elastic modulus

shear modulus (short term loading)

adhesion strength

ultimate compressive strength

The test specifications and acceptance criteria shall conform to those given in IRC: 83 (Part II).

#### 1402.4.8.2 *Acceptance testing Level 2*

General Inspection : This shall conform to the provisions in Clause 1402.4.8.1 in all respects.

Test on specially moulded test pieces : This shall conform to the provisions in Clause 1402.4.7.3.1 in all respects.

Test on complete bearings : Test for determination of shear modulus shall be conducted using two bearings of the lot selected at random and conforming to relevant provisions of Clause 1402.4.8.2. These bearings shall, however, be part of the lot accepted. The remaining tests stipulated in aforesaid clause shall be carried out on two bearings selected at random which shall be excluded from the lot accepted.

#### 1402.4.8.3 *Special acceptance inspection*

Special acceptance inspection may comprise the following :

i) Acceptance testing by an independent external agency with separate or supplemental test facilities provided by it.

ii) Acceptance testing on test pieces prepared from the surface or body of the test bearings instead of specially moulded test pieces.

iii) Acceptance tests not covered by these specifications but according to the specifications laid down by the Engineer.

Special acceptance inspection may be specified under the following conditions :

a) Special contract agreement

b) Evidence of unsatisfactory process or acceptance control

### **1402.4.9** *Inspection certificate*

A lot under inspection shall be accepted by the Inspector and so certified, when no defect is found with respect to any of the quality characteristics tested on samples drawn from the lot according to specifications laid down to Clause 1402.4.8 covering general inspection tests on specially moulded test pieces and on complete bearings.

In case any bearing is found defective, the lot shall be rejected by the Inspector and so certified.

In case any bearing is found to be defective with respect to any quality characteristic, discerned by general inspection tests specified in Clauses 1402.4.8 tests on specially moulded test pieces and complete bearings as applicable shall nevertheless be completed. If the said lot, rejected by general inspection, satisfies the acceptance criteria in respect of these other tests, the lot and individual bearings found defective shall be clearly identified in the inspection certificate.

The manufacturer shall obtain from the Inspector, authorized by the Engineer, immediately on completion of his inspection, an inspection certificate which shall include the details of a lot or lots accepted/rejected by him and records of all test measurements.

### **1402.4.10** *Quality control certificate*

The manufacturer shall certify for each lot of bearings under acceptance :

a) That an adequate system of continuous quality control was operated in his plant.

b) That the entire process remained in control during the production of the lot of bearings under acceptance, as verified from the quality control records/charts which shall be opened to inspection of Engineer/ Inspector on demand.

A certified copy of results of process control testing done on samples of elastomer used in the production of the lot shall be appended and shall include the following information:

Composition of compound – raw elastomer and ash content, the grade of raw elastomer used (including name, source, age on shelf), test results of hardness, tensile strength, elongation at break, compression set, accelerated ageing, etc.

A higher level certification of the process quality control shall be called for at the sole discretion of the Engineer in special cases e.g. where adequate inspection of bearings similar to those comprising the lot under inspection produced in the same plant, is not available with the Engineer or where there is any evidence of process or acceptance control being deemed unsatisfactory. The higher level certification shall comprise submittal of a complete quality control report as given in IRC:83 (Part II) supplementing the quality control certificate.

### **1402.4.11** *Acceptance*

The manufacturer shall furnish the following to Engineer for obtaining acceptance:

1) Quality control certificate as laid down in Clause 1402.4.10.

2) Inspection certificate as laid down in Clause 1402.4.9.

The manufacturer shall furnish any supplementary information on the system of quality control and/or process and accepted control testing as may be deemed necessary by the Engineer.

In case of any evidence of process or acceptance control testing being deemed unsatisfactory by him, the Engineer at his sole discretion may call for a special acceptance testing of the lot according to specifications laid down by him, without any prejudice to his right to reject the lot. The entire cost of such supplementary inspection shall be borne by the manufacturer.

The Engineer shall be the sole authority for acceptance of a lot on scrutiny of the certificates along with any supplementary evidence to his complete satisfaction.

In case of rejection of a lot, the Engineer shall reserve the right to call for special acceptance inspection for the succeeding lots offered for inspection, according to the specifications laid down by him. The entire cost of such tightened inspection shall be borne by the manufacturer.

### 1402.4.12 *Certification and marking*

Bearings shall be transported to bridge site after final acceptance by the Engineer and along with an authenticated copy of the certificate to that effect.

An information card giving the following details for the bearings, duly certified by the manufacturer shall also be appended:

Name of manufacturer
Date of manufacture
Elastomer grade used
Bearing dimensions
Production batch no.
Acceptance lot no.
Date of testing
Specific bridge location, if any
Explanation of markings used on the bearing

All bearings shall have suitable index markings identifying the information. The markings shall be made in indelible ink or flexible paint and if practicable should be visible after installation. The top of the bearing and direction of installation shall be indicated.

### 1402.4.13 *Storage and handling*

Each elastomeric bearing shall be clearly labelled or marked. The bearing shall be wrapped in a cover and packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges.

Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather of the bearings during transport and handling prior to and during installation.

### 1402.4.14 *Installation*

i) All the bearings installed along a single line of support shall be of identical dimensions.

ii) Bearings must be placed between true horizontal surfaces (maximum tolerance 0.2 percent perpendicular to the load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance + 3 mm).

iii) Concrete surfaces shall be free from local irregularities (maximum tolerance + 1 mm in height).

iv) Design shall be checked for the actual inclination in seating if larger inaccuracies than those specified are permitted.

v) For cast-in-place concrete superstructure, where bearings are installed prior to concreting, the forms around the bearings shall be capable of easy removal. Forms shall also fit the bearings snugly and prevent any leakage of mortar grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.

vi) For precast concrete or steel superstructure elements, fixing of bearing to them may be done by application of epoxy resin adhesive to interface, after specified surface preparation. The specifications for adhesive material, workmanship and control shall be approved by the Engineer. Care shall be taken to guard against faulty application and consequent behaviour of the adhesive layer as a lubricant. The bonding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearings against displacement for the purpose of design.

vii) As a measure of ample precaution against accidental displacement, the bearings shall be placed in a recess as per IRC:83 (Part II).

viii) In case seating of bearings on as non-horizontal plan is required shall be carried out in accordance with good engineering practice and as directed by the engineer

## 1402.5 Pot Bearings

### 1402.5.1 *General*

Pot bearings shall consist of a metal piston supported by a disc of unreinforced elastomer confined within a metal cylinder to take care of rotation. Horizontal movement, if required, shall be provided by sliding surfaces of PTFE pads sliding against stainless steel mating surfaces, with a system of sealing rings. Pot bearings shall consist of cast steel assemblies or fabricated structural steel assemblies.

### 1402.5.2 *Materials*

Structural steel, mild steel, high tensile steel and steel for forging shall conform to the requirements of Sections 1000 and 2000 of these Specifications.

Cast steel shall comply with Grade 280 - 520W or 340 - 570W of IS:1030.

Stainless steel shall conform to AISI 316 L or $O_2Cr_{17}Ni_{12}MO_2$ of IS:6911.

### 1402.5.3 *PTFE*

The raw material for PTFE used in bearings shall be pure polytetrafluoroethylene, free sintered without regenerated materials or fillers. The mechanical and physical properties of unfilled PTFE shall comply with Grade A of BS:3784 or equivalent. PTFE shall be either in the form of solid rectangular modules or large sheets with dimples formed by hot pressing or moulding. Sheet with dimples formed by machining or drilling from a solid PTFE sheet, shall not be permitted. The surface of PTFE sheets/modules which are to be in contact with metal backing plates, shall be provided with suitable chemical treatment for proper bonding. Adhesives used for bonding PTFE to backing plates, shall produce a bond with minimum peel strength of 4 N/mm width when tested in accordance with BS:5350 (Part C9).

### 1402.5.4 *Elastomer*

The elastomer to be used for the components of bearings shall comply with provisions of **Table 1400.1** of this Section.

The confined elastomer inside the pot shall have the properties as given in **Table 1400-3** :

**Table 1400.3 Properties of Confined Elastomer**

| | Property | Unit | Test Method – Specification Reference | Limiting Value |
|---|---|---|---|---|
| 1) | Hardness | IRHD | IS:3400 (Part II) | 50 ± 5 |
| 2) | Min tensile strength | MPa | IS:3400 (Part I) | 15.5 |
| 3) | Min elongation at break | | As per Table 1 of IRC:83 (Part II) | |
| 4) | Max compression set | | -do- | |
| 5) | Accelerated aging | | -do- | |

### 1402.5.5 *Composite material*

For guide of Pot bearings, composite material may be used for achieving lower coefficient of friction and higher strength. Such composite material shall consist of either (a) a bronze backing strip and a sintered inter-locking porous matrix impregnated and overlaid with a PTFE/lead mixture or (b) a mixture of PTFE, glass fibre and graphite embedded in a bronze mesh which is bonded to a galvanized steel backing strip.

### 1402.5.6 *Seals*

i) Internal seals shall be either of the following:

  a) Brass sealing ring made of metallic brass conforming to IS:410.

  b) Poly Oxy Methylene (POM) sealing chain of proven type consisting of individual interlocking elements made of moulded polyoxymethylene having properties as specified in IRC:83 (Part III).

ii) External seals shall be made of elastomer conforming to provisions of 1402.5.4.

### 1402.5.7 *Fasteners*

Bolts, screws, nuts and lock nuts, shall generally conform to IS:1363, IS:1364, IS:1365, IS:2269, IS:3138, IS:6761 and IS:6639 as appropriate with mechanical properties conforming to IS:1367. Threads shall generally conform to IS:4218.

### 1402.5.8 *Manufacture*

i) The main components of a bearing shall be cast/forged as a single monolithic body. If the same are made from mild steel, then they shall be machined to the desired shape from a single piece of mild steel free of laminations. No welding is permitted for manufacture of the main components of a bearing.

ii) The mating surface of the piston and cylinder of Pot bearings and that of the pin and cylinder of Pin bearings, shall be metallurgically hardened. The surface hardness shall not be less than 300 BHN.

iii) The guides shall always be monolithic with the parent component.

iv) For cast steel bearings, surfaces which will be in contact with concrete as well as non-working external surfaces of components may be kept in as-cast condition.

v) For sliding components, stainless steel sheet shall be attached to its backing plate by continuous fillet welding along the edges. The backing plate shall extend beyond the edges of the stainless steel sheet to accommodate the weld which should not protrude above the top of the stainless steel sheet.

vi) Suitable glue shall be used while confining the PTFE in the recesses. For large PTFE sheets sub-divided into parts, each individual part shall be confined into separate recess.

vii) For internal seal, split rings 2 mm thick and 20 mm wide made of metallic brass shall be provided in layers with staggered split positions. For elastomeric pressure pad of up to 480mm diameter, a minimum of 2 layers of rings shall be provided, while for that above 480mm diameter, a minimum of 3 layers of rings shall be provided.

viii) For internal seal of POM, the sealing chain made of individual interlocking elements shall be moulded as an integral part of the elastomeric pressure pad during the vulcanization process.

ix) Pre-setting of sliding element if required shall be done in the manufacturer's workshop before dispatch.

x) The bearing assembly shall be provided with temporary clamps to avoid separation of parts during transportation and installation.

xi) All welding shall be as per IS:816 and IS:9595, with electrodes as per IS:814. Preheating and post-weld stress relieving shall be done if required.

xii) Movement indicators shall be provided to facilitate routine inspection during service period.

xiii) All non-working surfaces as well as the surfaces to be in contact with the structure shall be suitably prepared by sand/short blasting to SA 2½ quality as per IS:9954.

xiv) All non-working surfaces shall be given suitable protective coating either by painting or by zinc spraying. The total dry film thickness of protective coating shall not be less than 160 μm.

xv) Painted protective coating shall comprise of two coats of epoxy primer enriched with metallic zinc, one intermediate coat of high build epoxy paint reinforced with MIO (Micaceous Iron Oxide) and one coat of high performance epoxy finish paint as per manufacturer's specification.

xvi) Bearing components to be embedded in concrete or surfaces of any component to be in contact with concrete, shall be given a coat of epoxy primer or any other suitable coating before dispatch to site.

xvii) Silicon grease shall be applied at the PTFE – stainless steel interface of Pot bearings.

xviii) The confined elastomeric pressure pad shall be lubricated with a suitable lubricant, which will not affect the material of the pad.

**1402.5.9** *Manufacturing tolerances*

i) The overall dimensions of any assembled bearing or any component thereof shall not exceed the tolerance limits as prescribed in IRC:83 (Part III).

ii) The tolerance on flatness of PTFE, the dimensional tolerance of confined PTFE and the tolerance of fit between different components of bearings shall be in accordance with IRC:83 (Part III).

**1402.5.10** *Inspection and testing*

i) Inspection and testing shall consist of the following actions:
   a) Inspection and testing of raw materials
   b) Process inspection
   c) Inspection and testing of finished bearings

ii) The manufacturer shall have all test facilities required for process and acceptance control tests, installed at his plant to the complete satisfaction of the Inspector appointed by the concerned authority. The test facilities and process operation shall be open for inspection by the Inspector at any time.

iii) A testing programme shall be drawn up and submitted by the manufacturer to the Inspector and his approval obtained before commencement of testing. All the test reports duly certified by the Inspector shall be furnished by the manufacturer at the time of dispatch of the bearing from the workshop.

iv) Routine test covering all the three items mentioned in i) shall be carried out by the manufacturer for the bearings of each lot under acceptance. In addition, type test covering items b) and c) of i) shall be carried out on bearings of each type and load capacity, selected at random by the Inspector, one for each lot. The size of each lot for similar type of bearings shall be 25 nos. or part thereof. Each type of bearing shall be treated as a separate lot. The Inspector may also carry out random tests on raw materials on samples drawn by the manufacturer, in which case the identification and marking of the sample will be done in the presence of the Inspector.

v) A detailed quality control report of routine tests shall be furnished by the manufacturer to the Inspector, for each lot of bearings offered for inspection.

### **1402.5.11** *Tests on raw materials*

Tests of raw materials as per relevant material standards shall be carried out by the manufacturer in accordance with IRC:83 (Part III).

### **1402.5.12** *Process inspection/tests*

i) Test on welding shall consist of DP test and visual inspection as per IS:822.

ii) The hardness of all major steel components shall be tested to determine the Brinnel Hardness Number (BHN), which shall be not less than 120 BHN for mild steel and 150 BHN for cast steel and forged steel.

iii) All major metallic components shall be ultrasonically tested as per Level 3 of IS:9565.

iv) The surface hardness of the mating interface shall be checked in accordance with the requirement specified in Clause 1402.5.8 (ii).

v) Corrosion protection shall be checked in accordance with the requirement specified in 1402.5.8 (ii).

vi) In case any of the acceptance control tests are deemed to be unsatisfactory by the Inspector, complete bearing or particular component(s) of the entire lot may be rejected, depending on the cause of rejection i.e. if the test of any material in unsatisfactory, the component involving that material shall be rejected for the entire lot; but if a finished bearing fails in load test, the complete bearing shall be rejected and all the bearings of that type and load capacity, shall be load tested before acceptance. If the result of process inspection is unsatisfactory, proper rectification measures shall have to be adopted by the manufacturer and the acceptance tests shall be repeated.

**1402.5.13** *Inspection/test of finished bearings*

i) All bearings of the lot shall be visually inspected for any defects in surface finish, shape or any other discernible superficial defects.

ii) All bearings shall be checked for overall dimensions as per manufacturing tolerances specified in Clause 1402.5.8.1.

iii) At least one or a pair of bearings of each type and different vertical load capacity, selected at random, shall be load tested. For Pot and PTFE bearings, the test load shall be 1.25 times the design vertical load while that for Pin and Metallic Guide Bearings, it shall be 1.25 times the specified design horizontal load. Additionally, for testing of Pot and PTFE bearings under a combination of loads acting in different axes, the test loads shall be 1.1 times the respective design loads. The test load shall be applied in stages and held for 30 minutes. For Pot bearings, the vertical deflection under sustained test load shall not increase by more than 4% of the thickness of the confined elastomeric pressure pad. The load shall then be removed and the bearing dismantled for visual examination.

iv) Visual examination of the test bearing shall be carried out both during and after the test. Any visual defects, such as physical damage, cold flow of PTFE resulting in reduction of height by more than 0.5mm, damage of internal seal and/or extrusion of the confined elastomeric pressure pad for Pot bearing, defects/cracks at metal to metal contact surfaces, shall lead to rejection of the bearing.

v) For bearings with sliding components, friction test shall be performed on properly lubricated PTFE-stainless steel sliding surface at constant vertical load equal to the design vertical load as well as the permanent vertical load. Horizontal load shall be applied till sliding occurs. Coefficient of friction (μ) shall be determined on the basis of applied vertical and horizontal loads and shall not exceed two-thirds of the value specified in IRC:83 (Part III), depending on the actual average pressure on PTFE due to the applied vertical load.

vi) Rotation test shall be performed on Pot bearing with properly lubricated elastomeric pressure pad for design rotation under a constant vertical load equal to the permanent vertical load.

### **1402.5.14** *Certification and marking*

i) Bearings should be transported to bridge site after final acceptance by the Inspector/inspection agency appointed by the concerned authority, along with an authenticated copy of the certificate of acceptance. An information card listing the required bearing characteristics, duly certified by the manufacturer should also be appended with the certificate.

ii) All bearings shall have suitable index markings in indelible ink or flexible paint, which if practicable, shall be visible even after installation, giving the following information:

- Name of manufacturer
- Month and year of manufacture
- Bearing designation
- Type of bearing
- Load and movement capacity
- Centre line markings to facilitate installation
- Direction of major and minor movement, if any
- Preset, if any

### **1402.5.15** *Installation*

#### *1402.5.15.1* *General*

i) Bearings shall be so located as to avoid the accumulation of dirt and debris on or around them. Detailing of the structure shall be such that water is prevented from reaching the bearings.

ii) Bearings should not normally be dismantled after leaving the manufacturer's workshop. However, if for any reason, a bearing is required to be dismantled, it shall be done only under expert supervision for which the manufacturer's help may be sought.

iii) Transfer of load from the superstructure to the bearings should not be allowed until the bedding material has developed sufficient strength. Temporary clamping devices should be removed at the appropriate time before the bearings are required to accommodate movement. The holes exposed on removal of temporary transit clamps should be filled with selected material. Where re-use of these fixing holes may be required, the material used for filling the holes should be capable of being easily removed without damaging the threads.

iv) Suitable temporary supporting arrangements under bearing base plates should be made to accommodate thermal movement and elastic deformation of the incomplete superstructure. Such temporary supports if provided should be removed once the bedding material has reached its required strength. Any voids left as a consequence of their removal should be made good using the same bedding material. Steel folding wedges and rubber pads are suitable for use as temporary supports.

1402.5.15.2 *Bedding*

i) The bedding material shall be selected keeping in view the type and size of bearing, construction sequence, load on the bearing and required setting time. Commonly used bedding materials are cementitious or chemical resin mortar and grout. In some cases, it may be necessary to carry out trials to ascertain the most suitable material.

ii) The bedding material, whether above or below the bearing, should extend over the whole area of the bearing in order to ensure even loading. After installation, there shall be no voids or hard spots. The top surface of any extension of the bedding beyond the bearing shall have a downward slope away from the bearing.

iii) The bedding material shall be capable of transmitting the applied load to the structure without being damaged. Surfaces to receive bedding mortar shall be suitably prepared so as to be compatible with the mortar chosen.

1402.5.15.3 *Fixing of bearings*

i) Bearings should be anchored in order to counter vibration and accidental impact. Anchorage should be accurately set into recesses cast into the structure using templates. The remaining space in the recesses should be filled with material capable of withstanding the loads.

ii) Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by anchorage or other means to prevent disturbance during subsequent operations. Voids beneath the bearings should be completely filled with bedding material using the appropriate method.

iii) Bearings may be fixed directly to metal bedding plates that may be cast in or bedded on top of the supporting structure to the correct level and location.

iv) If the structure is of steel, the bearings may be bolted directly onto it. Care shall be taken to ensure that there is no mismatch between the bolt holes of the structure and those of the bearing.

v) Threaded fasteners shall be tightened uniformly to avoid overstressing of any part of the bearing.

1402.5.15.4 *Bearings supporting in-situ concrete deck*

i) Where bearings are installed prior to casting of an in-situ concrete deck, formwork around bearings should be properly sealed to prevent grout leakage. It is essential that the bearings and particularly the working surfaces are protected during concreting operations. Sliding plates should be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under the weight of green concrete. Any mortar contaminating the bearings should be completely removed before it sets.

ii) For bearings supporting precast concrete or steel beams, a thin layer of synthetic resin mortar should be used between bearings and the beams. Bearings shall be bolted to anchor plates or sleeves embedded in precast concrete elements or to machined sole plates on steel elements.

#### *1402.5.15.5 Installation tolerances*

Bearings shall be located so that their centre lines are within ± 3 mm of their correct position. The level of a bearing or the mean levels of more than 1 bearing at any support, shall be within a tolerance of ± 0.0001 times the sum of the adjacent spans of a continuous girder, but not exceeding ± 5 mm. Bearings shall be placed in a horizontal plane within a tolerance of 1 in 200 in any direction, even under superstructure in gradient.

### 1402.6 Inspection and Testing

Where any patents are used, the manufacturer's certificate with test proofs shall be submitted alongwith the design and got approved from the Engineer before their use in work.

### 1402.7 Test and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

### 1402.8 Measurements for Payment

Bearings shall be measured in numbers, according to their capacities and particular specifications given on the drawings.

The quantity of elastomeric bearings shall be measured in cubic centimeters of finished dimensions.

### 1402.9 Rate

The contract unit rate of each type of bearing shall include the cost of manufacturing, supplying and fixing the bearings in position complete as specified on the drawings or as decided by the Engineer.

The rate shall also include the cost of samples and their testing when directed by the Engineer.

In case of steel bearings, the rate shall include the cost of all nuts, bolts, the cost of all tests prescribed in the specifications and shown on the drawings.

## 1403 EXPANSION JOINTS

### 1403.1 Description

This Section covers filler joint, asphaltic plug joint, reinforced elastomeric joint of slab seal, strip seal/box seal joint and compression seal joint. The work shall consist of fabrication and placing of expansion joints as indicated on the drawing and conforming to these specifications or as directed by the Engineer.

### 1403.2 General

**1403.2.1** The expansion joints shall be designed and duly got approved from the Engineer. It shall cater for expected movement and rotation of the structure at the joints and provide smooth riding surface. It shall also be easy for inspection, maintenance and replacement.

**1403.2.2** Expansion joints shall be robust, durable, water-tight and replaceable. Site fabricated expansion joints shall be prohibited. Expansion joints shall be obtained by the Engineer either directly or through the Contractor from approved manufacturers and be of proven type.

**1403.2.3** Basis for selection of expansion joints shall be as per guidelines given in IRC:SP:69. Buried, finger joint.

**1403.2.4** Proprietary type deck joints offered by the Contractor in lieu of the type specified shall comply in all respects with the manufacturer's specifications and meet the required range of movements and rotations and be fit for the purpose of ensuring satisfactory long term performance in the bridge.

**1403.2.5** Where alternative type proprietary deck joints are proposed by the Contractor, the following information shall be provided.

i) Name and location of the proposed manufacturer.

ii) Dimensions and general details of the joint including material specifications, holding down bolt or anchorage details and installation procedures.

iii) Evidence of satisfactory performance under similar environmental conditions of similar joints being produced by the manufacturer.

Any acceptance of alternative types will be at the sole discretion of the Engineer.

**1403.2.6** Vehicular traffic shall not be allowed over expansion joints after its construction for such period as may be determined by the Engineer.

Such deck joints shall be installed in accordance with the manufacturer's recommendations and to the general requirements of this Specification.

**1403.2.7** The expansion joint shall be provided to cover the entire carriageway, kerb and footpath, wherever provided. It shall follow the profile including the kerb, footway and facia. The type of expansion joint for the latter may be made different from that used for the carriageway expansion joint, however it shall cater to all movements including rotations for which the carriageway expansion joint is required to be designed and shall be water tight.

### 1403.3 Requirements

**1403.3.1** The requirement criterion will be separately applicable for the expansion joint proper and the transition zone of attachment to the deck.

**1403.3.2** There are two types of performance requirements for the expansion joint proper viz. from the necessity of the bridge and from the road users e.g. man, animal and vehicle.

**1403.3.3** Performance requirement with respect to bridges

The expansion joint shall :

i) Withstand the imposed load including the impact load from live load and other sources.

ii) Allow expansion and contraction movement due to temperature, creep, shrinkage, prestressing and structural deformations.

iii) Permit relative rotation in elevation and plan due to the causes as noted above.

iv) Be waterproof. Bridge deck expansion joint seals play a critical role in preventing the degradation of the structural components of the bridge system. Without effective joint seals, water passes through the bridge deck and work harmfully to corrode steel components and cause deterioration of the concrete. Rain water gathers various corroding additives from the atmosphere and also from the carriageway.

v) Ensure sealing. In case bridge deck joints are not sealed, apart from loss of waterproofing, grit and other forms of road debris may enter the joint. Debris, when impacted with the joint can seriously restrict the movement instead of facilitating the same. In the case of proprietary joints being accepted for adoption, the sealing shall be as specified by them.

vi) Ensure long life by being resistant to corrosion,

vii) Be easy to install,

viii) Be easy to maintain. Replaceability of expansion joint shall be one of the basic criteria for selection of type of expansion joint,

ix) Be resistant of the materials likely to collect/spill over the deck in its normal service.

**1403.3.4** *Performance requirement with respect to user*

The expansion joint shall:

i) Provide smooth continuity at the top of the deck for riding comfort,

ii) Be of skid resistant surface,

iii) Be non-damaging to the rubber tyre,

iv) Make minimum noise during vehicular crossing,

v) Ensure that animal paws and hooves should not get entangled where bridges are used by animal drawn traffic,

vi) Permit passing of bullock cart steel tyre for bridges where bullock carts ply,

vii) Look good aesthetically.

**1403.3.5** *Performance requirement for transition zone*

It is the zone of connection of joint assembly and the adjoining deck. The expansion joint shall:

i) Permit transfer of generated forces without distress, i.e., without getting uprooted. The purpose will not be served if the bonding is with the wearing coat only. Anchorage must be provided with the deck structural element.

ii) Ensure that surface in the transition zone stays undisturbed during long term service.

### 1403.4 Filler Joints

**1403.4.1** *Components:*

The components of this type of joint shall be at least 2 mm thick corrugated copper plate placed slightly below the wearing coat, 20 mm thick compressible fibre board to protect the edges, 20 mm thick pre-moulded joint filler filling the gap up to the top level of the wearing coat, sealed with a joint sealing compound.

**1403.4.2** *Material:*

i) The material used for filling expansion joint shall be bitumen impregnated felt, elastomer or any other suitable material, as specified on the drawings. Impregnated felt shall conform to the requirements of IS:1838, and shall be got approved from the Engineer. The joint filler shall consist of large pieces. Assembly of small pieces to make up the required size shall be avoided.

ii) Expansion joint materials shall be handled with care and stored under cover by the Contractor to prevent damage.

iii) Any damage occurring after delivery shall be made good to the satisfaction of the Engineer and at the expense of the Contractor.

**1403.4.3** *Fabrication and installation*

i) Joint gaps shall be constructed as shown on the drawings. Surfaces of joint grooves shall be thoroughly cleaned with a wire brush to remove all loose materials and dirt and debris, then washed or jetted out.

ii) Pre-moulded expansion joint filler shall not be placed in position until immediately prior to the placing of the abutting material. If the two adjacent surfaces of the joint are to be placed at different time, this type of joint filler shall not be placed until the second face is about to be placed.

iii) Sealants shall be installed in accordance with the manufacturer's recommendations.

iv) Sealants shall be finished approximately 3 mm below the upper surfaces of the joint.

v) Joint materials spilt or splashed onto finished surfaces of the bridge during joint filling operations shall be removed and the surfaces made good to the Engineer's approval.

vi) No joint shall be sealed until inspected by the Engineer and approval is given to proceed with the work.

### 1403.5 Reinforced Elastomeric Joint

#### 1403.5.1 *Components*

i) Steel Inserts: The elastomeric slab units shall be fixed to the steel inserts properly anchored in the deck concrete. Fixing of elastomeric slab units with anchoring bolts directly embedded in deck concrete shall not be permitted. Steel inserts along with anchorage shall be fabricated at manufacturers workshop and not at site.

ii) Anchorage: The anchorage shall either be loop anchors connected to the inserts by anchor plate or sinusoidal anchor bars welded with the horizontal leg of the steel inserts. For loop anchors with anchor plate, the thickness of the anchor plate shall not be less than 12 mm. Diameter of anchor loops shall not be less than 16 mm and the spacing of anchors shall not be more than 250 mm in any case. For sinusoidal anchors, diameter of bar shall not be less than 12 mm.

iii) Fixing bolts: Fixing bolts and nuts shall be made of stainless steel. Tightened nuts shall be locked by using lock washers.

iv) Elastomeric plugs: The plug holes provided in elastomeric slab units to house fixing bolts shall be plugged with elastomeric plugs pressed in position after applying adhesive on the appropriate surface.

v) Adhesives and sealants: Special sealant to be poured into the plug holes before plugging and special adhesive to be used for installation shall be as per the recommendation of manufacturer.

vi) Necessary spacer bars to ensure proper positioning of bolts and levelling and aligning steel inserts during fixing with deck as well as special jigs to be used to preset the elastomeric slab units shall be provided by the manufacturer.

**1403.5.2** *Material*

i) Mild steel to be used for manufacture of steel reinforcing plates, inserts and anchorage shall comply with Grade B of IS:2062.

ii) Cast steel to be used for manufacture of steel reinforcing plates shall comply with IS:1030.

iii) The elastomer to be used for manufacture of Elastomeric Slab Units shall comply with IRC:83 (Part II), compounded to give hardness IRHD 60 ± 5.

**1403.5.3** *Fabrication*

i) All surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete shall be sand/ shot blasted to SA 2½ and provided with a coat of epoxy primer enriched with metallic zinc. Surfaces not to be in contact with or embedded in concrete shall be provided with an additional coat of epoxy primer enriched with metallic zinc, one intermediate coat of high build epoxy paint reinforced with MIO (Micaceous Iron Oxide) and one coat of high performance epoxy finish paint as per paint manufacturer's specification with a minimum total dry film thickness of 150 micron.

ii) Elastomeric slab units: Elastomeric slab units shall be fully moulded to the required size in one single vulcanizing operation including the reinforcing plates and encasing layers as integral and homogenous part. Edges of reinforcing steel sections shall be rounded. The elastomeric slab units shall be manufactured generally as per IRC:83 (Part II). Adjoining portions of elastomeric slab units shall be provided with suitable male-female groove to ensure water tightness.

iii) Tolerances of fabrication shall be as follows :

  a) Plan dimension : ± 5 mm

  b) Total height : ± 3 mm

**1403.5.4** *Supply and handling*

i) The Contractor shall supply all steel-reinforced elastomeric expansion joints including bolts, nuts, sealant, plugs and all other accessories for the effective installation of the joints including angled jointing sections for kerbs.

ii) Expansion joint material shall be handled with care and stored under cover by the Contractor to prevent damage. Any damage occurring after delivery shall be made good at the expense of the Contractor to the satisfaction of the Engineer.

## 1403.6 Single Strip/Box Seal Joint

### 1403.6.1 *Components*

Strip seal expansion joint shall comprise the following items:

i) **Edge Beam:** This shall be either extruded or hot rolled steel section including continuously shop welded section with suitable profile to mechanically lock the sealing element in place throughout the normal movement cycle. Further, the configuration shall be such that the section has a minimum thickness of 10 mm all along its cross section (flange & web). Thickness of lips holding the seal shall not be less than 6 mm. The minimum height of the edge beam section shall be 80 mm. The minimum cross sectional area of the edge beam shall be 1500 mm$^2$.

ii) **Anchorage:** The edge beams of single strip/box seal joints shall be anchored in the concrete with rigid loop anchorage. The anchor loops shall be connected to the edge beam by means of anchor plate welded to the edge beam. Total cross sectional area of anchor loop on each side of the joint shall not be less than 1600 mm$^2$ per meter length of the joint and the centre to centre spacing shall not exceed 250 mm. The thickness of anchor plate shall not be less than 0.7 times the diameter of anchor loop or 12 mm whichever is higher. The anchor loop at the edge profiles should be at a right angle to the joint. Planned deviations of this direction are allowable only for the range of 90° +/-20°. (The anchoring reinforcement of the construction must lie parallel to the anchor loops).

iii) **Sealing element:** This shall be a preformed/extruded single strip of such a shape as to promote self-removal of foreign material during normal joint operation. The seal shall possess high tear strength and be insensitive to oil, gasoline and ozone. It shall have high resistance to ageing. The specially designed proprietary type of locking system of seal in the housing of edge beam shall be such to ensure 100 percent water tightness as well as ease of installation and replacement. Mechanical fastening of sealing element with edge beam shall not be permitted. Sealing element shall be continuous over the entire joint.

### 1403.6.2 *Material*

i) The steel for edge beams shall conform to any of the steel grade equivalent to RST 37-2 or 37-3 (DIN), S235JRG2 or S355K2G3 of EN10025 (DIN 17100), ASTM A 36 or A 588, CAN/CSA Standard G40.21 Grade 300 W and Grade B of IS:2062. For subzero condition, material for steel shall conform to IS:2062 Grade C.

ii) The sealing element shall be made of Choloroprene Rubber (CR). The properties of CR shall be as specified in **Table 1400.4**.

The working movement range of the sealing element shall be at least 80 mm with a maximum of 100 mm at right angles to the joint and ± 40 mm parallel to the joint.

Joint for which the gap width does not close fully, the movement capacity shall be (80-minimum opening) i.e. the capacity of the joint having a minimum opening gap width of 20 mm will be 60 mm. Only for joints that close fully, the movement capacity of joint shall be 80 mm.

Minimum gap for inserting the Chloroprene seals in the expansion joint shall be 25 mm.

iii) All steel sections shall be protected against corrosion by one of the following two methods:

a) Hot dip galvanizing with a minimum thickness of 150 micron

b) Epoxy coating

All surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete shall be sand/ shot blasted to SA 2½ and provided with a coat of epoxy primer enriched with metallic zinc. Surfaces not to be in contact with or embedded in concrete shall be provided with an additional coat of epoxy primer enriched with metallic zinc, one intermediate coat of high build epoxy paint reinforced with MIO (Micaceous Iron Oxide) and one coat of high performance epoxy finish paint as per paint manufacturer's specification with a minimum total dry film thickness of 150 micron.

iv) Anchorage steel shall conform to Grade B of IS:2062 or equivalent standard.

**Table 1400.4 Properties of Chloroprene Seal**

| **Property** | **Standard** | **Specific Value** |
|---|---|---|
| Hardness | DIN 53505<br>ASTM D 2240 * | 63 ± Shore A<br>55 ± Shore A |
| Tensile Strength | DIN 53504<br>ASTM D 412* | Min. 11 Mpa<br>Min 13.8 Mpa |
| Elongation at fracture | DIN 53504<br>ASTM D 412* | Min. 350%<br>Min. 250% |
| Tear propagation strength longitudinal transverse | DIN 53507<br>ASTM D 624* (Dia C) | Min 10N/mm<br>Min 10M/mm |
| Shock elasticity | DIN 53512 | Min. 25% |
| Abrasion | DIN 53516 | Max. 220 mm$^3$ |

| | | |
|---|---|---|
| Residual compression strain (22h/70°C/30% strain) | DIN 53517<br>ASTM D 395* (Method B) | Max 28% |
| Ageing in hot air (14 days/70°C)<br>Change in hardness<br>Change in tensile strength<br>change in elongation at fracture | DIN 53508 | <br>Max. + 7 Shore A<br>Max. – 20%<br>Max. – 20% |
| Ageing in ozone (24h/50pphm/25°C/20% strain) | DIN 53509 | No cracks |
| Swelling behavior in oil (168h/25°C)<br>ASTM oil No. 1<br>Volume Change<br>Change in hardness<br>ASTM oil No. 3<br>Volume Change<br>Change in hardness | DIN 53521 | <br><br>Max. + 5%<br>Max. – 10 Shore A<br><br>Max. + 25%<br>Max. – 20 Shore A |
| Cold hardening point | ASTM D 1043 | Min. 35°C |
| ***Note:*** Only one set of specification viz., ASTM or DIN shall be followed depending on the source of supply. | | |

**1403.6.3** *Fabrication (Pre-installation)*

i) Rolled steel profiles for edge beams shall be long enough to cater for the full carriageway width. These shall be cut to size of actual requirements by means of a mitre box saw. Alignment of the cut-to-size steel profiles shall then be made in accordance with the actual bridge cross-section on work tables. For this purpose, the contour of bridge cross-section shall be sketched onto these tables. After the steel profiles are aligned, they will be chucked to the tables by means of screw clamps and tacked by arc welding.

ii) Anchor plates shall be cut to the required size by gas cutting. These shall be welded to the edge beams.

iii) Anchor loops shall be bent to the required shape and welded to anchor plates.

iv) The finally assembled joints shall then be clamped and transported to the work site.

**1403.6.4** *Handling and storage*

i) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.

ii) The manufacturer shall supply either directly to the Engineer or to the Contractor all the materials of strip seal joints including sealants and all other accessories for the effective installation of the joint.

iii) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding by the Contractor to prevent damage. Any damage occurring after delivery shall be made good at the Contractor's expense to the satisfaction of the Engineer

### 1403.7 Asphaltic Plug Joint

#### 1403.7.1 *Component*

i) This joint shall consist of a polymer modified bitumen binder, carefully selected single size aggregate, closure/bridging metallic plate and heat resistant foam caulking/backer rod

Asphaltic Plug Joint shall be used to cater for a maximum horizontal movement up to 25 mm and maximum vertical movement of 2 mm. This shall be certified by the manufacturer/supplier of the joint.

ii) The joint shall be capable of performing satisfactorily, within the temperature (ambient) range of -5 to 50°C

#### 1403.7.2 *Material*

i) **Binder:** The polymer modified bitumen binder shall have the capacity to fill the gaps and voids between single size aggregate and to impart flexibility to accommodate various design movements. It shall be a patented blend of bitumen, synthetic polymer, fillers and surface active agent and shall be so formulated as to combine necessary fluidity for the installation process, low temperature flexibility and flow resistance at high ambient temperatures. The binder shall satisfy following requirement:

| | | |
|---|---|---|
| Softening point | : | 100°C minimum |
| Cone penetration at 25°C, 0.1 mm (BS 2499) | : | 100 mm max |
| Flow resistance at 70°C, 5 hours (BS 2499) | : | 3 mm max |
| Extension Test | : | 5 cycle of extension to 50 percent (blocks prepared to ASTM D1190 at a rate of 3.2 mm/hour at and tested to limits BS 2499) 25°C |
| Safe heating temperature | : | 210°C |

ii) **Aggregates:** The aggregate shall be single size aggregate chosen from basalt granite, grit stone or gabro group. The nominal size of aggregate shall be 12.5 mm for depths of joints up to 75 mm; to 20 mm for joints of more depth. The aggregate shall not be flaky and the Flakiness Index shall not be more than 25 percent. The aggregate shall satisfy grading requirements stipulated in **Table 1400.5**.

**Table 1400.5 Grading Requirements of Aggregate**

| IS Sieve Designation | Nominal Size of Aggregate | |
|---|---|---|
| | 20 mm | 25 mm |
| | Percentage by Weight Passing the Sieve | |
| 26.5 mm | 100 | - |
| 19.9 mm | 85-100 | 100 |
| 13.0 mm | 0-35 | 85-100 |
| 09.5 mm | 0-7 | 0-35 |
| 06.3 mm | - | 0-7 |
| 02.3 mm | 0-2 | 0-2 |
| 75 micron | 0-1 | 0-1 |

The aggregate should have good (i) Polished Stone Value (PSV). (ii) Aggregate Abrasion Value (AAV). (iii) Aggregate Impact Value (AIV) and (iv) Aggregate Crush Value (ACV). In addition surface characteristics should promote proper adhesion. The following are the required values:

PSV > 60

AAV > 05

AIV < 18

ACV = 10-25

iii) **Closure Plate:** The closure plate shall be weldable structural steel conforming to IS:2062. The minimum thickness of steel plate shall be 6 mm and the width shall not be less than 200 mm. Closure plate shall be provided with as large length as possible and welded together to form the required length. The number of pieces shall not be more than two per traffic lane width. It shall be provided with equidistant holes at a maximum spacing of 300 mm centres for anchorage to the caulking/backer rod along the longitudinal centre line of the plate. The plate shall be protected against corrosion by galvanizing or any other approved anti-corrosive coating paint with a minimum thickness of 100 micron.

iv) **Foam Caulking/Backer Rod:** A closed cell polyolefine or open cell polyurethane foam cylindrical caulking or backer rod having diameter equal to 150 percent of the joint opening shall be provided. It shall be heat resistant and possess good flexibility and recovery characteristics with density of 25 to 30 kg/m$^3$.

## 1403.8 Compression Seal Joint

### 1403.8.1 *Component*

i) Compression seal joint shall consist of steel armoured nosing at two edges of the joint gap suitably anchored to the deck concrete and a preformed chloroprene elastomer or closed cell foam joint sealer compressed and fixed into the joint gap with special adhesive binder.

ii) **Steel nosing :** The steel nosing shall be of angle section ISA 100 x 100. The thickness of legs shall not be less than 12 mm. The top face of the angle shall be provided with Bleeder holes of 12 mm diameter spaced at maximum 100 mm centres so as to ensure that there are no voids in the concrete beneath the angle.

iii) **Anchorage:** The steel nosing shall be anchored to the deck by reinforcing bars or anchor plates cast in concrete or a combination of anchor plates and reinforcing bars. Anchor bars shall engage the main structural reinforcement of the deck and in case of anchor plates and anchor loops, this shall be achieved by passing transverse bars through the loops or plates. The minimum thickness of anchor plates shall be 12 mm. Total cross sectional area of bars on each side of the joint shall not be less than 1600 sq. mm per m length of the joint and the centre to centre spacing shall not exceed 250 mm. The ultimate resistance of each anchorage shall not be less than 600 kN/m in any direction. Steel shall conform to Grade B of IS:2062. For sub zero condition, material for steel shall conform to IS:2062, Grade C.

iv) **Joint Seal:** The sealing element shall be a preformed continuous chloroprene/closed cell foam seal with high tear strength, insensitive to oil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness. The seal should be continuous for the full length of the joint required for carriageway, kerbs and footpaths, if any. The seal shall cater for a horizontal movement up to 40 mm and vertical movement of 3 mm.

### 1403.8.2 *Material*

i) The material of steel nosing and anchorage conforming to weldable structural steel as per IS:2062 Grade B shall be used.

ii) The physical properties of chloroprene/closed cell foam sealing element shall conform to the following:

a) **Chloroprene Seal:** Shall be preformed extruded multi-web cellular section of chloroprene of such a shape as to promote self removal of foreign material during normal service operations. Chloroprene of joint seal shall satisfy the properties stipulated in **Table 1400.4**.

b) **Closed Cell Foam Seal:** This shall be of preformed non-extruded non-cellular section made from low density closed cell, cross linked ethylene vinyl acetate, polyethylene copolymer that is physically blown using nitrogen. The material shall posses properties as indicated in **Table 1400.6**.

**Table 1400.6 Properties of Closed Cell foam Seal**

| Property | Special Value |
|---|---|
| i) Density | 41.7-51.3 kg/cum |
| ii) Compression set on 25 mm | 50 percent compression samples (ASTM D 3575) for 22 hours at 23 °C, 2 hour recovery; 13 percent set. |
| iii) Working temperature | -70 to +70 °C |
| iv) Water absorption (total immersion for 3 months) (ASTM 3575) | 0.09766 kg/sqm |
| v) Tensile Strength | 0.8 MPa |
| vi) Elongation at break (ASTM D 3575) | 195+/-20 percent. |

c) **Chemical Tests:** Chemical tests shall be performed on specimens of elastomer and the properties shall conform to the values/ standards indicated in **Table 1400.7**.

**Table 1400.7 Chemical Tests**

| Adhesion Strength | IS:3400 pt XIV | 7 kN/m |
|---|---|---|
| Low temperature stiffness | ASTM D-797 | Young modulus 70 N/mm$^2$ (max) |
| Ash Content | IS:3400 pt XXII | 5% |
| Polymer identification test (infrared spectro photometry) | ASTM D 3677 | Comparison of spectra with reference to sample of polychloroprene |

iii) **Lubricant cum Adhesive:** The type and application of material used in bonding the preformed joint seal to the steel nosing and concrete shall be as recommended by the manufacturer/supplier of the seal system.

iv) **Corrosion Protection:** All steel section shall be protected against corrosion by hot dip galvanizing or any other approved anticorrosive coating with a minimum thickness of 150 micron.

### 1403.9 Installation of Expansion Joints

#### 1403.9.1 *General procedure*

i) Expansion Joints shall be installed under thorough supervision of the manufacturer's/ supplier's engineer in order to ensure the quality of installation so that expansion joints function as intended during their entire life span. Detailed Installation Manual shall be supplied by the joint manufacturer.

ii) The dimensions of the recess in the decking shall be established in accordance with the drawings or design data of the manufacturer, taking the width of gap for movement of the joint into account.

iii) The presetting of Expansion Joint shall be done by means of an auxiliary construction

iv) The road surfacing/wearing coat shall be laid before commencing installation of joint. Before laying wearing coat, the recess portion shall be filled with sand and wearing coat shall be laid in a continuous manner over the deck slabs and recess portion. Prior to the installation of the joints, portion of wearing coat over the recess shall be removed by a suitable method e.g. saw cutting and the infill sand shall be removed subsequently.

v) **Preparation of the Recess:** The recess shall suit in size and form to the geometry of the expansion joint. However, the width shall not be less than the specified value for a particular type of joint. In order to avoid difficulties during installation, the following points must be checked and considered:

- Dimension check of recess
- Check of the levels
- Check of the skew and slope
- Check of the designed gap between bridge deck and abutment and/or between adjoining decks
- Checking of the existing structural reinforcement according to the drawings

  Missing rebars shall be replaced by inserting bars penetrating sufficiently deep into the concrete. Rebars that would obstruct the installation of the expansion joint shall be bent to accommodate the expansion joint anchorages. Removing or cutting off interfering reinforcing bars shall only be done after consultation with the Engineer.

  The recess shall be cleaned thoroughly. If necessary, the surface should be roughened. All loose dirt and debris shall be removed by wire brushing, air blowing and dried with hot compressed air.

vi) **Shuttering:** Shuttering must be used to seal the space between the underside of the joint and the vertical face of the recess. The shuttering must be fitted in such a way that it forms an appropriate seal against the edge of the recess. The recess shall be shuttered in such a way that dimensions in the drawing are maintained. The formwork shall be rigid and firm.

vii) **Placing in the Recess:** Level marks shall be set next to the recess. This enables a controlled leveling of the expansion joint. Lowering the expansion joint/joint construction/insert into the recess shall be done in such a way that the entire length of the joint is evenly lowered into the recess. Thereafter, the joint/joint construction/insert is precisely leveled and adjusted in the longitudinal, transverse and vertical planes. If required,

viii) **Connection**

a) It is recommended to install the expansion joint/joint construction/insert in the early morning when the temperature is distributed almost uniformly over the whole bridge. Immediately before the installation, the actual temperature of the bridge shall be measured. If it is not within the considered tolerance, the preset adjustment shall be corrected. The joint/joint construction/insert shall be lowered in a predetermined position. Following placement of the joint/joint construction/insert in the prepared recess, the joint/joint construction/insert shall be levelled and finally aligned and the anchorage steel on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side. With the expansion joint/joint construction/ insert finally held at both sides, the auxiliary brackets shall be released, allowing it to take up the movement of the structure. After carrying out the final fixing, the protection against corrosion shall be completed.

b) For fully assembled joints with one end fixed and other end movable e.g. modular strip/box seal joint, connection shall be as detailed below:

- **The 1st side:** The fixed side of the assembled joint (either the abutment or the bridge deck side) is designated the 1st side for connecting the joint. The preliminary fixing is made by evenly placing and welding of rebars over the entire length between the anchor loops and the deck reinforcement. To facilitate concreting, it is recommended that the gap between recess and shuttering is sealed by a grout seam. The seam must be left to dry prior to final concreting. After this, additional rebars are welded until all anchor loops are firmly connected to the deck reinforcement. The expansion joint is sufficiently fixed when no vibration is noted when lightly bouncing on the joint. The expansion joint shall not be subjected to any loads that could in any way displace the precise location of this fixing.
- **The 2nd side:** Depending on the size of the expansion joint and the expected movement during the installation, the most suitable time must be determined for the fixing of the 2nd (moveable) side.

Usually this is the early morning hours with the smallest temperature deviations. The procedure is identical to that at the 1st side. As fast as possible, preferably with several fitters at the same time, the joint shall be provisionally fixed to the reinforcement.

Immediately afterwards, the fixation brackets shall be removed. Thereafter, the gap between recess and shuttering shall be sealed with grout seam and the remaining rebars welded as described previously.

ix) **Concreting**

a) Prior to final concreting, the position of the joint/joint construction/insert must be recorded. The Engineer must give written confirmation of the correct position of the joint and recess concreting. The recess shall be thoroughly watered. Before pouring the concrete, the joint construction should be protected by a cover. Controlled concrete having strength not less than that in superstructure subject to the minimum of M35 shall be filled into the recess. The water cement ratio shall not be more than 0.4, if necessary admixtures may be used to improve workability. The filling concrete must feature low shrinkage. The freshly placed concrete shall be properly vibrated. Damage to the shuttering shall be avoided during vibration. The filling concrete shall be finished flush with the carriageway surfacing. The concrete shall be kept damp until it has cured in order to avoid fissures caused by drying too fast. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

b) For modular strip seal joint, the space beneath the joint boxes shall be completely filled with concrete, so that traffic loads are safely transmitted into the structure.

x) As soon as the concrete in the recess has become initially set, a sturdy ramp shall be placed over the joint to protect it from traffic at site. Expansion joint shall not be exposed to traffic loading before completion of carriageway surfacing.

xi) The elastomeric sealing element may be field installed. For strip seal and modular strip seal joints, the sealing element shall be in continuous lengths spanning the full carriageway width. Proper fit of the seal of the sealing element must be ensured. The seal shall be installed without damage to the seal by suitable hand method or machine tools.

**1403.9.2** *Specific procedure for asphaltic plug joint*

i) The recess in the deck slab, if required, shall be repaired with epoxy mortar and cleaned and dried again.

ii) The foam caulking/backing rod shall be placed about 25 mm down into the joint opening.

iii) The aggregate shall be washed, cleaned and heated to a temperature between 120-180°C prior to placement.

iv) The binder shall be preheated to temperature of 170-190°C before application.

v) While sealing the joint opening with preheated binder, care shall be taken that the binder does not spill on to the joint surface of the deck.

vi) The joint shall not be installed when the ambient temperature goes below +5°C or above +35 °C or while it is raining/snowing. Planning for installation shall take into account the weather condition.

vii) When work is resumed after stoppage, due to weather condition, the joint installation shall be continued after the upper layer and/or exposed surface of the partially completed joint has been prepared by heating and/or coating with binder as necessary.

viii) The joint shall be provided over the entire width of the structure including kerb and/or footpath. A recess in the kerb and/or footpath shall be made to allow the joint to pass beneath them. The expansion gap in the adjoining kerbs and/or footpaths shall be sealed with a suitable sealant such as polysulphide sealant.

ix) The joint shall extend to the full depth of the wearing course down to structural concrete. Where needed, a recess may be cut into the deck slab concrete to accommodate the minimum required depth (75 mm) of the joints.

x) The minimum width (in traffic direction) of the joint shall be 500 mm and maximum width shall be 750 mm.

xi) Minimum depth of joint shall be 75 mm and maximum depth shall not exceed 100 mm.

**1403.9.3** *Specific procedure for compression seal joint*

i) The dimension of the joint recess and the width of the gap shall conform to the approved drawing.

ii) Anchoring steel shall be welded to the main reinforcement in the deck maintaining the level and alignment of the joint

iii) The width of the pocket shall not be less than 300 mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess.

iv) At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.

v) The lubricant cum adhesive shall be applied to both faces of the joint and joint seal prior to installation in accordance with the manufacturer's instructions.

vi) The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation which shall be between +5 to +35°C.

vii) The joint seal shall be installed without damage to the seal. Loose fitting or open joints shall not be permitted.

### 1403.9.4 *Specific procedure for single strip/box seal joint*

i) The width of the gap to cater for movement due to thermal effect prestress, shrinkage and creep, superstructure deformations (if any) and sub-structure deformations (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is likely to be installed, the gap dimension shall be preset.

ii) Immediately prior to placing the joint, the presetting shall be inspected. Should the actual temperature of the structure be different from the temperature provided for presetting, correction of the presetting shall be done. After adjustment, the brackets shall be tightened again.

iii) Rolled up neoprene strip seal shall be cut into the required length and inserted between the edge beams by using a crow bar pushing the bulb of the seal into the steel grooves of the edge beams. A landing to a bead shall be formed in the thickened end of the edges of the seal which would force the thickened end against the steel beam due to wedge effect when the strip seal is buttoned in place.

iv) The carriageway surfacing shall be finished flush with the top of the steel sections. The actual junction of the surfacing/wearing coat with the steel edge section shall be formed by a wedge shaped joint with a sealing compound. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

### 1403.9.5 *Specific procedure for reinforced elastomeric joint*

*1403.9.5.1* Expansion joints shall be installed as per approved drawing. Steel inserts, spacer bars, concreting of pockets, fixing of elastomer slab unit and presetting shall be done as per the following:

i) Steel Inserts

   a) Deck casting shall be done leaving pockets or recess for steel inserts and anchors of the expansion joint as per drawing.

b) Steel inserts shall be lowered at the appropriate location inside the pocket.

c) The top of the insert shall be flush with the finished level of wearing course maintaining the camber.

d) Spacer bars, duly set appropriately to the month of installation, shall be fitted under proper supervision.

e) Anchor rods shall be tied/welded with the existing deck main reinforcement, maintaining level and alignment.

f) Welding between anchor rods and deck reinforcement is preferable. If welding is not possible, strong steel tie wires shall be used for fastening under proper supervision.

ii) Spacer Bar

a) Spacer bars shall be used to ensure proper positioning of bolts and also leveling of the steel inserts during fixing of the same with the deck reinforcement and casting second stage concreting in the pocket thereafter.

b) The 2nd stage concreting operation shall preferably be started within 24 hours of fixing the steel inserts. In such cases, spacer bars should be removed just after concreting is finished. If there is a substantial time lag between fixing of inserts and concreting, then any one of the following methods shall be adopted, depending on the support condition :

i) For simply supported bridge resting on simple elastomeric bearings, (with no dowel pins), insert shall be placed in position with spacer bars at every alternate joints. Such joints shall be called restrained joints hereafter. In other words, inserts shall not be fixed simultaneously at two ends of one span. If the above condition is satisfied, inserts with spacer bars shall be kept in position for a substantially longer period at such restrained joints. Spacer bars shall be removed after concreting of such restrained joints and inserts placed in position with spacer bars at the other unrestrained joints thereafter.

ii) For bridges resting on other than elastomeric bearings (including bearings with dowel pins at one end), after placing and aligning the inserts and securing the same, the spacer bars shall be removed. Concreting shall be done with great care so that inserts are not dislocated or distorted.

c) While removing the spacer bar after concreting, one must take care to see that the concrete is not damaged during withdrawal of spacer bar. If the spacer bar happens to be snugly fitted, it shall not be pulled by any means; it shall be gas cut in two pieces and then removed.

iii) Concreting of Pocket

a) Concreting of pocket shall be done with great care using proper mix conforming to grade similar to that of the deck casting besides ensuring efficient bonding between deck and steel insert. Also proper care shall be given for ensuring efficient bonding with the already cast concrete.

b) Needle vibrators shall be used. Care shall be taken so that the position of steel insert is not disturbed during vibration.

c) Spacer bar shall be removed within an appropriate time before the joint is required to permit movement.

iv) Fixing of Elastomeric Slab Unit (ESU)

a) Special jig shall be used to preset the ESU during installation

b) ESU (mounted on the jig, if preset) shall be lowered to position.

c) The line and level on the ESU should be adjusted.

d) ESU shall be removed and coated with special adhesive

e) ESU shall be placed in position again, ensuring waterproof joining at required faces.

f) ESU shall be tightened with stainless steel nuts and lock washers in position. Tightened nuts shall be locked with lock washers.

g) Special sealant shall be poured inside the plug holes.

h) The elastomeric plugs shall be pressed in position after applying adhesive on the appropriate surface.

i) ESU shall be fitted in position after completion of wearing course. While completing this part of the wearing course, adequate care shall be taken to ensure a waterproof joining with the already existing wearing course.

v) Pre-Setting

a) The main purpose of presetting of the steel inserts at the time of its installation is to ensure as closely as possible the condition that in the long run at the mean average annual temperature, the ESU remains at its nominal state.

b) Major factors responsible for changing the longitudinal length of the bridge superstructure are indicated below :

- Temperature variation from annual mean.
- Changes due to shrinkage of concrete.

- Changes due to elastic shortening and creep of the prestressed bridge superstructure.
- Deformation of superstructure and substructure, if any.

  Resultant changes in expansion gap due to first factor can occur in both directions from any pre-selected mean position whereas changes due to creep and shrinkage are unidirectional such that the expansion gap continuously increases with passage of time.

The steel insert unit of expansion joint can be fixed in any month of the year. As stated earlier, the expansion gap between bridge superstructure may vary from time to time; hence the initial fixing distance between fixing points will obviously depend on the month of installation of steel insert. The c/c distance between stainless steel fixing of bolts as indicated in the drawing can be taken as only nominal. The same shall be modified by presetting depending on :

i) The difference between the mean temperature of the month of fixing of steel insert and the annual average temperature.

ii) The elapsed period between the casting and/or prestressing and fixing of steel insert for calculating the remnant creep and shrinkage.

vi) Special requirements for installation

a) Prior to construction of bridge deck area adjacent to the joint, the supplier shall provide detailed working drawings showing the location of all bolts, recesses and holes necessary for the installation of the joint. Reinforcing bars in superstructure shall be amended as required to ensure that there will be no interference in the installation of the joint.

b) All bearing surfaces and recesses which are in contact with the joint assembly shall be checked with a straight edge to ensure flatness of profile.

c) No holes shall be drilled for fixing bolts within 7 days of concreting. Holes for the bolts shall be drilled to the size and depth shown on the drawings.

d) Sections of the jointing making the completed joint shall follow a straight line.

e) The fixing bolts shall not be placed in a position until at least 4 weeks after stressing is completed in post-tensioned box or beam and slab structures. Prior to placing sections of jointing, contact surfaces shall be cleaned to remove all grease, tar, paint, oil, mud or any other foreign material that may affect adhesion of the sealant.

f) Sealant shall only be applied to dry contact surfaces. Sufficient sealant shall be applied to the contact surfaces to cause extrusion of sealant when the jointing is fixed in position.

g) Final sealing of the finished expansion joint shall be completed immediately after completion of installation. All exposed ends, joints between units and other areas of possible leakage shall be filled with sealant. All voids between the sides of the jointing and concrete or plates shall be filled with sealant.

h) Bolt cavities shall be cleaned and plugged with neoprene cavity plugs. Prior to placing the plugs sufficient sealant shall be placed in the cavities to cause extrusion of the sealant by the plugs.

i) All excess sealant shall be removed from the jointing and adjacent areas

### 1403.10 Testing and Acceptance Standards

**1403.10.1** Before installing joints in a bridge, sufficient evidence of the reliability of the proprietary products shall be furnished. A copy of the following fatigue and wear test report, as applicable depending upon the type of joint, carried out by a recognized laboratory/university/institute on the joint components as a part of product development test shall be furnished once for the entire lot of supply. The tests covered in i) to v) below need not be carried out on the materials of the joints of supply lot but shall be carried out from time to time by the original manufacturer as per their product development and quality plan for the same type of joints to ensure the performance requirement of the particular joint component against fatigue and/or wear.

i) For single strip seal and modular strip seal joints, the manufacturer shall produce complete report of the test of anchorage system in a recognized laboratory to determine optimum configuration of anchorage assembly under dynamic loading in support of the efficacy of the anchorage system adopted for the joints of entire lot of supply.

ii) For modular strip seal joints, the manufacturer shall produce a test report from a recognized laboratory that the sliding bearings (suspension system) have been fatigue tested for 6x106 (6 million) load cycles with a frequency of 5 Hz and the loads for these durability tests are 80 kN, 120 kN and 160 kN.

iii) For modular strip seal joints, the manufacturer shall produce a test report from a recognized laboratory that the wearing of sliding interface of bearings of modular joints has been tested for a total sliding distance of 5000 m at a load of 48 kN.

iv) For modular strip seal joints, the manufacturer shall produce a test report from a recognized laboratory that the sliding material of sliding springs of expansion joints has been tested for a total sliding distance of 20,000 m with a load equivalent to a stress of 30 MPa.

v) For modular strip seal joints, the manufacturer shall produce a test report from a recognised laboratory that the butt-welded splicing of centre beams has been tested with 2x106 (2 million) load cycles with a load equivalent to a stress of 165 MPa.

vi) In case of Reinforced elastomeric joints, abrasion resistance test shall be carried out in accordance with IS:3400 (Pt 3) or DIN 53516.

vii) An expansion joint assembly in a bridge deck shall have minimum number of joints, subject to the manufacturer's specifications for the proprietary products.

### **1403.10.2** *Pre-installation criteria*

The pre-installation criteria shall include the following off-site tests:

#### *1403.10.2.1 Routine tests*

Routine tests including tests for materials conforming to specifications shall be carried out by the original manufacturer i.e., in case of imported joints by the foreign manufacturer as part of their quality control procedure for all joints to be supplied by them. Detailed documentation of all the tests and inspection data as per complete quality control procedure shall be supplied by the original manufacturer in the form of Quality Control Report. Routine tests shall primarily include:

- Raw materials inspection
- Process inspection
- Complete dimensional check as per approved drawings

i) Raw material inspection

Test on all raw materials used for the manufacturing of joints as per relevant material standard based on this specification shall be carried out by the manufacturer.

ii) Confirmation of the grade of steel

Grade of the steel for the edge beam shall be confirmed by conducting tests for yield stress, tensile strength and elongation. Corresponding to RST 37-2 or 37-3 or 52-3 (DIN), S235 JRG2 or S355K2G3 of EN10025 (DIN 17100), ASTM A36 or A 588, CAN/CSA standard G 40.21 grade 300 W or equivalent to Grade B of IS:2062. The manufacturers/suppliers shall have in-house testing facilities for conducting these tests.

iii) Steel for the anchorage should conform to IS:2062 for Single Gap Strip Seal Joints.

iv) The following tests as indicated in Table 1400.1 should be made for checking the properties of the Chloroprene Seal: (a) Hardness (b) Tensile strength (c) Elongation at fracture (d) Tear propagation strength (e) Residual compressive strain (f) Change in hardness (g) Change in tensile strength (h) Change in Elongation at fracture (i) Ageing in ozone and (j) Swelling behavior in oil. The manufacturers/suppliers shall have in-house testing facilities for conducting these tests.

#### *1403.10.2.2 Process inspection*

Process inspection including inspection of all manufacturing processes adopted to manufacture the joints e.g., welding, corrosion protection, clamping, presetting, greasing, bonding by adhesives and riveting, as appropriate, shall be carried out by the manufacturer.

#### *1403.10.2.3 Complete dimensional check*

Complete dimensional check of all components of joint as well as the assembled joint with respect to the approved drawings and tolerances as per this specification, shall be carried out by the manufacturer.

#### *1403.10.2.4 Acceptance tests*

In addition to the tests specified under Clause 1403.10.2.1.1, the manufacturer as well as the local supplier in case of imported joints shall have complete in-house testing facilities for the following tests. The client shall insist upon these tests before acceptance of the joint.

i) Cyclic motion

Cyclic motion test may be carried out once on one complete joint assembly or one meter sample piece selected at random from the entire lot of supply for each type of joint irrespective of movement capacity. The test sample shall be subjected to 5000 expansion and contraction cycles @ minimum 30 cycles per hour. The test movement shall be 10% more than the design expansion/contraction movement. Any sign of distress or permanent set of any component or the assembly due to fatigue will cause rejection of entire lot of supply.

ii) Ponding

Prior to acceptance, 25 percent of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25 mm above the highest point of deck. The width of ponding shall be at least 50 mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25 mm anytime during the test. A close inspection of the underside of the joint shall not reveal any leakage.

iii) Debris expelling test

Debris expelling test shall be carried out on one meter sample piece selected at random from the entire lot of supply. The fully open gap shall be filled flush with granular debris and cycled 25 times for full opening and closing. The mass of debris repelled after 25 cycles shall be expressed as the percentage of initial mass. The percentage expelled shall not be less than 75 percent.

iv) Pull-out test

Pull-out test shall be carried out on one meter sample piece selected at random from the entire lot of supply. The joint shall then be stretched until the sealing element slips off from its housing. The minimum stretching of the joint before slip-off shall be least 150% of the rated movement capacity of the seal.

v) Vehicular braking/traction test

This is the only initial acceptance (inhouse) test. Needed facility for carrying out this test shall be available with the manufacturer. This test may be carried out once on one complete joint assembly or one meter sample piece selected at random from the entire lot of supply for each type of Joint irrespective of movement capacity. The test sample shall be installed between two blocks of concrete in its mean position. A truck wheel load of 40 kN shall be drawn across the specimen with an engaged ratchet with wheel locked to stimulate locked brakes and then rolled back. The cycle shall be repeated for 50,000 times with a period of 2 seconds. Continuous water cooling will be necessary to control excessive heat generated during the test.

vi) Arrangement for protection of steel sections against corrosion should be checked.

*1403.10.2.5 Applicability of acceptance tests on different types of joints*

The acceptance tests described in Clause 1403.10.2.4 shall be applicable as per **Table 1400.8** for different types of joints:

**Table 1400.8 Applicability of Acceptance Tests on Different Types of Joints**

| Performance Evaluation Tests | Asphaltic Plug Joint | Compression Seal Joint | Reinforced Elastomeric Joint | Single Gap Strip/Box Seal Joint | Modular Strip/Box Seal Joint |
|---|---|---|---|---|---|
| Cyclic motion | Not Applicable | Applicable | Applicable | Applicable | Applicable |
| Ponding | Not Applicable | Applicable | Applicable | Applicable | Applicable* |
| Debris expelling test | Not Applicable | Applicable | Applicable | Applicable | Applicable* |
| Pull-out test | Not Applicable | Not Applicable | Not Applicable | Applicable | Applicable* |
| Vehicular braking/ traction test | Not Applicable | Not Applicable | Applicable | Applicable | Applicable* |

* For modular strip seal expansion Joint ponding test, debris expelling test, pull-out test and vehicular braking test shall be carried out on one meter edge beam samples only, complete with sealing element and anchorage (mandatory for vehicular braking test), to be supplied by manufacturer.

***Note:*** For all expansion joints which are proprietary, a minimum guarantee of 10 years for their satisfactory performance shall be given by the contractor.

### 1403.11 Tests and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

### 1403.12 Measurements for Payment

The expansion joint shall be measured in running metres.

### 1403.13 Rate

In the case of supply and installation contract, the contract unit rate shall include the cost of all material, labour, equipment and other incidental charges for procuring and fixing the joints complete in all respects as per these specifications. For filler joints, the rate per running metre shall include the cost of sealant for the depth provided in the drawing.

In the case of supply contract, the contract unit rate shall include cost of all components of expansion joint including anchorage system, pre installation fabrication and transportation of assembled joints and other incidental charges, as directed by the Engineer.

In the case of Installation only contract, the contract unit rate shall include the cost of all material, labour, equipment and other incidental charges for installation of the joints complete in all respects as per these specifications.

## 1404 WEARING COAT AND APPURTENANCES

### 1404.1 Scope

This section includes specification for wearing coat and bridge appurtenances such as railing, crash barrier, approach slab, drainage spouts. The work shall be executed in conformity with details shown on the drawings and these specifications or as approved by the Engineer.

### 1404.2 Wearing Coat

### 1404.2.1 *Bituminous wearing coat*

Bituminous wearing coat shall comprise of 20 mm thick premix carpet with seal coat on culverts having earth cushions and pavement carried over such culverts. On minor bridges and culverts having no earth cushion, 50 mm thick Bituminous Macadam (BM) covered with 25 mm thick Semi Dense Bituminous Concrete shall be used.

For major bridges, bituminous wearing coat shall comprise of following types:

| | |
|---|---|
| Type 1: | Bituminous Concrete 50 mm thick laid in single layer |
| Type 2: | Bituminous Concrete 40 mm thick overlaid with 25 mm thick mastic asphalt |
| Type 3: | Stone Matrix Asphalt 50 mm thick laid in single layer |
| Type 4: | Mastic Asphalt 50 mm thick laid in single layer |

Before laying wearing coat, the deck surface shall be thoroughly cleaned and tack coat shall be applied. For the culverts and minor bridges, the construction operations and bituminous mixes shall conform to Section 500 of these Specifications. In case of major bridges, the construction operations and bituminous mixes for wearing coat type 1,2,3 and 4 shall conform to Section 500 of MORTH Specifications.

### 1404.2.2 *Cement concrete wearing coat*

Cement concrete wearing coat shall be laid separately over the bridge deck. The thickness of wearing coat shall be 75 mm. The concrete shall be of minimum M30 grade. Steel reinforcement of 8 mm diameter @ 150 mm spacing in both directions shall be provided at the mid depth of the wearing coat. In a length of 1 m near the expansion joint additional reinforcement of 8 mm diameter bars shall be provided in both directions to make the spacing as 75 mm.

Cement concrete and steel reinforcement shall conform to Sections 800 and 1000 respectively of these Specifications.

Curing of wearing coat earlier than what is generally required may be resorted to, so as to avoid formation of shrinkage cracks in hot weather.

All carriageway and footpath surfaces shall have non-skid characteristics.

**1404.2.3** The cross slope in the deck shall be kept as 2.5 percent.

**1404.2.4** For the structures with flat deck surface camber/superelevation shall be achieved in the wearing coat as below:

i) In bituminous wearing coat, provide profile corrective course before laying wearing coat. The profile corrective course shall be of the same material as of wearing coat.

ii) In case of cement concrete wearing coat, provide profile corrective course along with wearing coat in single layer.

**1404.2.5** Overlay on the existing wearing coat on bridge decks shall not be permitted. In case the wearing coat is damaged, it shall be repaired or replaced.

## 1404.3 Railings, Crash Barrier and Kerbs

### 1404.3.1 *General*

a) Bridge railing/crash barrier includes the portion of the structure erected on and above the kerb for the protection of pedestrians and traffic.

b) Railing/crash barriers shall not be constructed until the centering falsework for the span has been released and the span is self-supporting. For concrete with steel reinforcement, specifications of the items of controlled concrete and reinforcement mentioned under relevant sections of these specifications shall be applicable.

c) The type of railing/crash barrier shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. The pockets left for posts shall be filled up with non-shrinkable mortar.

d) The type of railing/crash barrier to be constructed shall be as shown on the drawings and shall conform to IRC:5 and IRC:6.

e) Care shall be exercised in assembling expansion joints in the railing/ crash barriers to ensure that they function properly.

f) The bridge railing/crash barriers shall be amenable to quick repairs.

g) Railing/crash barrier materials, particularly metal railing/crash barriers, shall be handled and stored with care, so that the material and parts are kept clean and free from damage. Railing/crash barrier materials shall be stored above the ground on platforms, skids, or other supports and kept free from grease, dirt and other contaminants.

Any material which is lost, stolen or damaged after delivery shall be replaced or repaired by the Contractor. Methods of repair shall not damage the material or protective coating.

**1404.3.2** *Metal railing/crash barriers*

All complete steel rail elements, pipe terminal sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanised or painted with an approved paint.

If galvanised, all elements of the railing/crash barrier shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by the Engineer.

Damaged galvanised surfaces, edges of holes and ends of steel railing/crash barrier cut after galvanising shall be cleaned and re-galvanised.

The railing/crash barrier shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing/crash barrier in place in the structure at proper grade and alignment.

Unless otherwise specified on the drawings, metal railing/crash barrier shall be given one shop coat of paint and three coats of paint after erection if sections are not galvanised.

Railing/crash barriers shall not follow any irregularity in the alignment of the deck. When shown on the drawings, the rail elements shall be curved before erection.

### 1404.3.3 *Cast-in-situ concrete railing/crash barriers*

The portion of the railing/crash barrier or parapet which is to be cast in place shall be constructed in accordance with the requirements for Structural Concrete in Section 800. The reinforcement shall conform to Section 1000.

Forms shall either be of single width boards or shall be lined with suitable material duly approved by the Engineer. Form joints in plane surfaces will not be permitted.

All mouldings, panel work and bevel strips shall be constructed according to the details shown on the drawings. All corners in the finished work shall be true, sharp and clean-cut and shall be free from cracks, spalls or other defects. Castings of posts shall be done in single pour.

### 1404.3.4 *Precast concrete railing/crash barriers*

Precast members for railing/crash barriers shall be of reinforced cement concrete and shall conform to the specifications given in Sections 800 and 1000. The maximum size of the aggregate shall be limited to 12 mm and the concrete grade shall be M30. The precast members shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days. During this period, they shall be protected from sun and wind. Any precast member that becomes chipped, marred or cracked before or during the process of placing shall be rejected. Special care shall be taken to watch the surface of the cast-in-situ portion of the deck.

### 1404.3.5 *Railings for submersible bridges*

#### *1404.3.5.1 General*

a) The railing shall be metal railing of collapsible or removable type or tubular railing as specified on the drawings. Fixed type railings consisting of RCC vertical posts and RCC/Tubular horizontal members or solid parapet type or post and chain type railing shall not be permitted.

b) Collapsible railing shall be used where it is necessary to put up the railings immediately when the bridge is opened to traffic after a submerging flood has receded. The design of these railings shall be such as to ensure that they fit well in their grooves and are not liable to be dislodged by floods.

c) Removable type railings shall be adopted when there is no danger to the traffic using the bridge for short period without railings. The design of these railing shall be such as to ensure that the various members are interchangeable and can be easily removed and refitted.

d) Collapsible or removable railings shall be strong enough to resist same forces as applicable for railings or parapets on high level bridges. The arrangement shall be such as to ensure that the railings do not collapse on carriageway side.

e) Guide posts/stones shall not be permitted in bridge portion and their use shall be restricted to the approach portion of the bridge.

f) The design of bridge railings shall be such, which is amenable to quick removable, erection and repairs.

g) Railing materials, particularly metal railings, shall be handled and stored with care, so that the material and parts are kept clean and free from damage. Railing materials shall be stored above the ground on platforms, skids, other supports and kept free from grease, dirt and other contamination. Any material which is lost, stolen or damaged after delivery shall be replaced or repaired by the Contractor. Methods of storage, etc. or repairs shall not damage the material or protective coating.

#### *1404.3.5.2 Kerbs on submersible bridges*

Continuous kerb on deck shall not be permitted. The kerb shall be discontinuous with 300 mm wide gap at 1.8 m center to center (i.e., 1.5 m continuous length) on both sides. The gaps provided in kerbs shall be opposite to each other to permit free flow of flood waters. The outer face of the kerb shall be given streamline shape as shown on the drawings or as directed by the Engineer. Construction of kerb including pockets for fixing railings shall conform to the provisions of Sections 800 and 1000 of these Specifications.

### 1404.4 Approach Slab

Reinforced concrete approach slab with 12 mm dia bars at 150 mm c/c in each direction both at top and bottom in M30 grade of concrete covering the entire width of the roadway shall be provided as per details given on the drawings or as approved by the Engineer. Minimum length of approach slab shall be 3.5 m and minimum thickness 300 mm.

The cement concrete and reinforcement shall conform to Sections 800 and 1000 respectively.

The base for the approach slab shall be 150 mm thick M15 grade of concrete or as shown on the drawings or as directed by the Engineer.

### 1404.5 Drainage Spouts

**1404.5.1** This work shall consist of furnishing and fixing in position of drainage spouts and drainage pipes for bridge decks.

Drainage along longitudinal direction shall be ensured by sufficient number of drainage fixtures embedded in the deck slab. The spouts shall be of not less than 100 mm in diameter and shall be of corrosive resistant material such as galvanised steel with suitable cleanout fixtures. The spacing of drainage spouts shall not exceed 10 m. The discharge from drainage spout shall be kept away from the deck structure. In case of viaducts in urban areas, the drainage spouts should be connected with suitably located runners and down pipes to discharge the surface run-off to drains provided at ground level.

### 1404.5.2 *Fabrication*

The drainage assembly shall be fabricated to the dimensions shown on the drawings; all materials shall be corrosion resistant; steel components shall be of mild steel conforming to IS:226. The drainage assembly shall be seam welded for water tightness and then hot-dip galvanised.

### 1404.5.3 *Placement*

The galvanised assembly shall be given two coats of bituminous painting before placement. The whole assembly shall be placed in true position, lines and levels as shown in the drawings with necessary cut-out in the shuttering for deck slab and held in place firmly. Where the reinforcements of the deck are required to be cut, equivalent reinforcements shall be placed at the corners of the assembly.

### 1404.5.4 *Finishing*

After setting of the deck slab concrete, the shrinkage cracks around the assembly shall be totally sealed with polysulphide sealant or bituminous sealant as per IS:1834 and the excess sealant trimmed to receive the wearing coat. After the wearing coat is completed, similar sealant shall be finished to cover at least 50 mm on the wearing coat surface all round the drainage assembly.

## 1404.6 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall meet the prescribed criteria and requirements.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

## 1404.7 Measurements for Payment

The measurement for payment for wearing coat, railing/crash barriers, approach slab, and drainage spout shall be made as under :

i) Wearing coat shall be measured in cubic metres. Steel reinforcement in wearing coat shall be measured in tonnes.

ii) Railing and metal beam crash barriers shall be measured in running metres.

iii) For concrete crash barriers, concrete shall be measured in cubic metres and steel shall be measured in tonnes.

iv) Approach slab and its base shall be measured separately in cubic metres.

v) Drainage spouts shall be measured in numbers.

### 1404.8 Rate

The contract unit rate for wearing coat shall include the cost of all labour, material, tools and plant and other cost necessary for completion of the work as per these specifications.

The contract unit rate of railing and crash barriers shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications.

The contract unit rate for approach slab shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications. The rate for base shall include cost of all labour, material, tools and plant required, including preparation of surface and consolidation complete in all respects.

The contract unit rate for drainage spout shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications. It shall also include the cost of providing flow drain pipes with all fixtures upto the point of ground drains wherever shown on the drawings.

# 1500

# CEMENT CONCRETE PAVEMENT

# 1500 CEMENT CONCRETE PAVEMENTS

Cement concrete pavements shall be recommended selectively and restricted to be built in special cases only, where drainage of surface water is an acute problem, such as, in built-up areas or other isolated stretches. These pavements can also be used where other engineering conditions justify their use. These shall also be provided in stretches as directed by the Engineer, for example, in special situations such as in flood prone areas or where there is recurring problem of water logging.

## 1501 PLAIN CEMENT CONCRETE PAVEMENT

### 1501.1 Scope

**1501.1.1** The work shall consist of construction of unreinforced, plain cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the work, as approved by the Engineer. Semi mechanized method of construction shall be acceptable.

**1501.1.2** The design details, viz., thickness of pavement slab, grade of concrete, joint details, etc. shall be as shown on the drawings or as directed by the Engineer.

### 1501.2 Materials

**1501.2.1** *Source of materials*

The Contractor shall indicate to the Engineer, the sources of all materials to be used in the concrete work with relevant test data sufficiently in advance and the approval of the Engineer for the same shall be obtained at least 30 days before the scheduled commencement of the trial work. If the Contractor later proposes to obtain materials from a different source, he shall notify the Engineer and seek his approval with relevant test data, at least 30 days before such materials are to be used.

**1501.2.2** *Cement*

Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer.

i) Ordinary Portland Cement, 43 Grade IS:8112 or with fly ash not more than 30 percent by weight of cementitious material.

ii) Ordinary Portland Pozzolana Cement, IS:1489

iii) Portland Blast Furnace Slag Cement IS:455

iv) Ordinary Portland Cement (OPC), 53 grade (IS:12269) or with fly ash not more than 30 percent by weight of cementitious material.

*1501.2.2.1* If the soil around has soluble salts like sulphates in excess of 0.5 percent, by weight of soil, the cement used shall be sulphate resistant and shall conform to IS:12330.

*1501.2.2.2* Cement shall be obtained in bags or in bulk form if bulk storage containers are available. The cement shall be subjected to acceptance tests prior to its use.

If bag splitters are used, it shall be ensured that no paper pieces are fed into the concrete mixer.

### 1501.2.3 *Admixture*

*1501.2.3.1* Chemical admixture conforming to IS:6925 and IS:9103 shall be permitted to improve workability of the concrete.

*1501.2.3.2 Mineral admixture*

Flyash when used shall conform to IS:3812 (part 1).

### 1501.2.4 *Aggregates*

Aggregates for pavement concrete shall be natural material complying with IS:383 but with a Los Angeles Abrasion Test result not more than 35 percent or wet Aggregate Impact Value(AIV) not more than 30 percent. The limits of deleterious materials shall not exceed the requirements set out in IS:383. The aggregates shall be free from chert, flint, chalcedony or other silica in a form that can react with the alkalies in the cement. The total chlorides content expressed as chloride ion content shall be not more than 0.06 percent by weight and total sulphate content expressed as sulphuric anhydride ($SO_3$) shall not exceed 0.25 percent by weight.

*1501.2.4.1 Coarse aggregates*

Coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The aggregate shall not have flakiness index more than 35 percent. The maximum size of coarse aggregates shall not exceed 31.5 mm for pavement concrete. No aggregate which has water absorption more than 5 percent shall be used in the concrete mix. Where the water absorption is more than 3 percent, the aggregates shall be tested for soundness in accordance with IS:2386 (Part 5). After 5 cycles of testing, the loss in weight of aggregate shall be not more than 12 percent if sodium sulphate solution is used, or 18 percent if magnesium sulphate solution is used. The AIV shall not be more than 30 percent.

*1501.2.4.1.1* Dumping and stacking of aggregates shall be done in an approved manner. In case, the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hours before batching as directed by the Engineer.

*1501.2.4.2 Fine aggregates*

The fine aggregates shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS:383. Fine aggregates shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter.

*1501.2.4.2.1* The fine aggregate shall not contain deleterious substances more than the following limits:

| | |
|---|---|
| Clay lumps | 1 percent |
| Coal and lignite | 1 percent |
| Material passing IS Sieve No.75 micron | |
| i) Natural sand (Uncrushed) | 3.0 percent |
| ii) Crushed sand | 8.0 percent |

*1501.2.4.3* *Aggregate gradation*

The coarse and fine aggregates shall be blended so that the material after blending conforms to **Table 1500.1**:

**Table 1500.1 Aggregate Gradation for Pavement Quality Concrete**

| Sl. No | Sieve Designation | Percentage by Weight Passing the Sieve |
|---|---|---|
| 1) | 31.50 mm | 100 |
| 2) | 26.50 mm | 85-95 |
| 3) | 19.0 mm | 68-88 |
| 4) | 9.50 mm | 45-65 |
| 5) | 4.75 mm | 30-55 |
| 6) | 600 micron | 8-30 |
| 7) | 150 micron | 5-15 |
| 8) | 75 micron | 0-5 |

**1501.2.5** Steel bars for dowels and tie bars:

*1501.2.5.1* *Dowelbars*

Plain steel bars as per IS:432 (Part 1) having minimum yield strength 240 N/mm$^2$ shall be used as dowel bars.

*1501.2.5.2* *Tie bars*

Tie bar shall be of TMT steel conforming to IS:1786 and will have minimum yield stress of 500 N/mm$^2$ or more.

**1501.2.6** *Water*

Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirement stipulated in IS:456.

### 1501.2.7 *Premoulded joint filler board*

Bitumen impregnated filler board/pre-moulded synthetic joint filler board for expansion joints which are provided at abutting structures, like bridges and culverts, shall be of 20 mm thickness within a tolerance of ± 1.5 mm and of a firm compressible material and complying with the requirement of IS:1838. It shall be 25 mm less in depth than the thickness of the slab within a tolerance of ± 3 mm and provided to the full width between the side forms. It shall be in suitable lengths which shall be not less than one lane width. Holes to accommodate dowel bars, if used, shall be accurately bored or punched out to give a sliding fit on the dowel bars.

### 1501.2.8 *Joint sealing compound*

The joint sealing compound shall be of hot poured sealing compound type having flexibility, resistance to age hardening and durability conforming to IS:1834.

### 1501.2.9 *Storage of materials*

All materials shall be stored in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for the work, as described in Section 2000 of these Specifications.

*1501.2.9.1* *Storage of cement* Cement shall be stored at site in accordance with Section 2000 of these Specifications. The cement older than three months from the date of manufacture shall not be used.

## 1501.3 Mix-Design

**1501.3.1** After approval by the Engineer of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighed proportions of all ingredients for the approval of the Engineer. The mix design shall be submitted at least 30 days prior to the paving of trial length and the design shall be based on laboratory trial mixes using the approved materials and method as per IRC:44 or IS:10262. The mix design shall be based on the flexural strength of concrete. The strength of concrete shall be as specified in the Contract drawings. Where there are no facilities for testing beam samples for determining flexural strength, the mix-design may be carried out with the written permission of the Engineer using equivalent compressive strength value. The co-relation between flexural strength and compressive strength may be adopted, as below:

$f_f = 0.7 \sqrt{f_{ck}}$ $f_f$ = flexural strength, N/mm$^2$.

$\sqrt{f_{ck}}$ = characteristic compressive cube strength N/mm$^2$.

**1501.3.2** The Contractor shall carry out laboratory trials of design mixes with the materials from the approved sources to be used. Trial mixes shall be made in presence of the Engineer or his representative and the design mix shall be subject to the approval of the Engineer. These shall be repeated, if necessary, until the proportions that will produce a concrete which complies in all respects with these Specifications, and conforms to the requirements of the design/drawings.

*1501.3.2.1* The proportions determined as a result of the laboratory trial may be adjusted if necessary during the construction of the trial length, with the approval of the Engineer.

*1501.3.2.2* Any change in the source of materials or mix proportions proposed by the Contractor during the course of work shall be assessed for suitability by making laboratory trial mixes and shall be subject to the approval of the Engineer.

**1501.3.3** *Cement content:* The cement content shall not be more than 425 kg nor less than 350 kg per cum of concrete.However, if the contractor is not able to adhere the characteristic strength of concrete specified in the contract with 350 kg per cum, he shall increase the quantity of cement accordingly. He shall not be paid any extra cost for using the additional cement. If flyash is used to replace a part of cement in the concrete mix, the cement content shall not be less than 270 kg per cum. The flyash content may be upto 30 percent by weight of cementitious material.

**1501.3.4** *Concrete strength*

The concrete mix shall be of minimum M30 grade and its design shall be based on the flexural strength of concrete. The target average strength for the mix design shall be obtained from the following relationship:

$$S = S^1 + Za^* \nabla$$

where,

S = target average flexural strength, at 28 days, in MPa

$S^1$ = characteristic flexural strength, at 28 days, in MPa.

Za = normal variate, for rural roads, the tolerance level of 1 in 20 is recommended, for which Za=1.65.

$\nabla$ = Standard Deviation in MPa, this is expected standard deviation of field test samples in MPa.

**1501.3.5** The characteristic flexural strength of concrete shall be as specified in the contract drawings. The characteristic flexural strength at 28 days shall be not less than 3.8 MPa.

### 1501.4 Workability

The workability of the concrete shall be measured at the point of placing with slump cone test as per IS:1199. It shall be adequate for the concrete to be fully compacted and finished without undue flow. A slump value of 30 ± 10 mm is reasonable for paving work but will be adjusted depending upon the site requirement, ambient temperature, wind velocity and relative humidity. Chemical admixtures/plasticizer as per IS:9103 may be used if needed to achieve the workability, without affecting the strength and other properties of concrete. The maximum water cement ratio/water cementitious material ratio shall be not more than 0.50. The water content per batch of concrete should be maintained constant including suitable allowances to be made for free moisture and absorption by aggregates during storage.

### 1501.5 Subgrade

The subgrade shall conform to the grades and cross-sections shown on the drawings and shall be uniformly compacted to the design strength in accordance with Section 300 of these Specifications. The DLC/WBM Grade 3/ Cement treated soil (if used) shall be laid and compacted on the subgrade before laying the quality concrete. No PQC shall be laid directly on the subgrade even if the subgrade CBR is high. All vegetable and extraneous matter shall be removed from the subgrade. The sub-base shall not be laid on a subgrade softened by rain after its final preparation.Surface trenches and soft spots, if any, must be properly back-filled and compacted to avoid any weak or soft spot. As far as possible, the construction traffic shall be avoided on the prepared subgrade. A day before placing of the sub-base, the subgrade surface shall be lightly sprinkled with water and rolled with one or two passes of a 80 to 100 kN static or vibrating roller after a lapse of 2-3 hours in order to stabilise loose surface. If the Engineer considers it necessary and so directs, another fine spray of water may be applied just before placing the sub-base (DLC/WBM Gr. 3/Cement-lime treated soil). The CBR of the subgrade shall be not less than 4 percent. In case, it is less than 4 percent the CBR will be improved by stabilization with mechanical / lime-fly ash / lime/cement so as to bring the CBR not less than 10 percent.

### 1501.6 Sub-base

**1501.6.1** The cement concrete pavement shall be laid over Granular Sub-Base (GSB) or water bound macadam(WBM) Gr. 3(53-22.4 mm) or lime treated soil of thickness varying from 75 mm to 150 mm depending upon the volume and type of traffic. Where the sub-base soil is stabilized, the 4 days soaked CBR after 3 days curing with wet gunny bags shall be not less than 15.

**Sub-base types**

Traffic up to 50 CVPD: 75 mm thick compacted Water Bound Macadam Grade III (WBM III)/ Wet Mix Macadam (WMM) may be provided over 100 mm granular subbase made up of gravel, moorum or river bed material with CBR not less than 30 percent; Liquid Limit (LL) less than 25 percent and Plasticity Index (PI) less than 6. If aggregates are not available within a reasonable lead, 150 mm of cement/lime/lime-flyash treated marginal aggregate/ soil layer with minimum unconfined strength(UCS) of 3 MPa at 7 days with cement or at 28 days with lime/ lime-flyash may be used. The stabilized soil should not erode as determined from wetting and drying test (IRC:SP:89:2010).

Traffic from 50 to 150 CVPD:75 mm thick WBM III/WMM layer over 100 mm of granular material may be used as a subbase. Alternatively, 100 mm thick cementitious granular layer with a minimum unconfined strength(UCS) of 3 MPa at 7 days with cement or 28 days with lime/lime-flyash over 100 mm thick cementitious naturally available materials with a minimum UCS of 1.5 MPa with cement at 7 days or with lime or lime-flyash at 28 days may be provided.

Traffic from 150 to 450 CVPD:150 mm thick WBM III/WMM over 100 mm of granular subbase may also be used. Alternatively,100 mm of cementitious granular layer with a minimum

UCS of 3 MPa at 7 days with cement or at 28 days with lime or lime-flyash over 100 mm of cementitious layer with naturally occurring material with a minimum UCS of 1.5 MPa at 7 days with cement or at 28 days with lime or lime flyash. Cementitious marginal aggregates may be preferred over WBM/WMM in many regions having acute scarcity of aggregates as directed by the Engineer.

**1501.6.2** The granular subbase and WBM layers shall meet the requirements of Section 400 of these specifications. Commercially available IRC accredited stabilizers with no harmful leachate also may be used if found successful on trials and as directed by the Engineer.

### 1501.7 Separation Membrane

A separation membrane may be used between the concrete slab and sub-base if instructed by the Engineer. Separation membrane shall be impermeable PVC sheet transparent or white in colour and 125 micron thick laid flat with minimum creases. Before placing the separation membrane, the sub-base shall be swept clean of all extraneous materials. Wherever overlap of plastic sheaths is necessary, the same shall be at least 300 mm and any damaged sheathing shall be replaced at the Contractor's cost. The separation membrane may be nailed to the lower layer with concrete nails. It will be ensured that PVC sheets are not manufactured out of recycled plastic.Alternatively, the separation can also be provided by sprinkling bitumen VG 10 @ 2 kg/m$^2$ and sprinkled with sand passing through 4.75 mm and retained on 2.36 mm sieves.

### 1501.8 Joints

**1501.8.1** The location and type of joints shall be as shown in the drawings. Normally in pavements upto 200 mm thick, no dowel bars will be provided, if otherwise not required by the designer. In pavements more than 200 mm thick, 25 mm dia round steel dowel bars shall be used in transverse joints and expansion joints as per Section 1500 of these Specifications. In the pavement, less than 200 mm thick, transverse joints at a spacing 2.5 to 3.75 m centre to centre shall be cut with saw cutter to a depth of 25 to 30 mm and width of 3 to 5 mm. For pavements upto 200 mm thick, the load transfer shall be through aggregate interlock. This cut will be made in the freshly laid concrete after 8 to 10 hours of laying so as to avoid ravelling. These joints will remain unsealed. After a period of 8 to 10 years, such pavements will lose the aggregate interlock. After that period, these pavements will be provided with dowel bars by retrofitting. Longitudinal cut 40 mm wide and 500 mm long and 10 mm deeper than the half depth of the slab shall be made at 300 mm centre to centre. Four numbers in each wheeled path. The dowel bars shall be placed in these at mid depth and shall be filled with rapid hardening cement concrete and cured for three days (Refer IRC:SP:83). Joints shall be constructed depending upon their functional requirement as detailed in the succeeding paragraphs.

*1501.8.1.1* The location of the joints should be transferred from drawings, accurately at the surface of sub-base and marked on either side with red paint. Saw cutting of joints of pavement slab as per stipulated dimensions should be done when concrete is neither too soft nor too hard. Sawing operations could start as early as possible depending upon the season.

The initial saw cutting and subsequent widening of groove shall be done with the help of saw cutting machine with diamond studded blade. It shall be ensured that the required depth of cut is made from edge-to-edge of the pavement. Transverse and longitudinal joints in the pavement (PQC) and DLC (if used) sub-base shall be staggered so that they are not co-linear vertically and are at least 800 to 1000 mm apart in PQC and 300 to 400 mm apart in DLC.

Sawing operation should start at the earliest after laying of PQC preferably after 5-6 hours but not later than 18-20 hours depending upon the ambient temperature, wind velocity, relative humidity and required maturity of concrete achieved for this purpose.

### 1501.8.2 *Transverse joints*

Transverse joints shall be contraction, construction and expansion joints constructed at the spacing described in the drawings. Transverse joints shall be straight along the intended line of joints, which is the straight line transverse to the longitudinal axis of the carriageway. Except at road junctions or roundabouts, where the position shall be as described in the drawings, transverse joints on each side of the longitudinal joints, if provided, shall be in line with each other and of the same type and width.

### 1501.8.3 *Contraction joints*

The Contraction joint shall consist of a mechanically sawn joint groove 3 mm to 5 mm wide and upto 1/4 to 1/3 depth of the slab as shown on the drawings. The sawn joints shall be cut as soon as the concrete has undergone initial hardening and is strong enough to bear the weight of crew and the cutting machine. These joints shall be subsequently widened to 10 mm width and depth of 20 mm by appropriate saw to house the sealant. These joints shall be spaced 2.5 m - 3.75 m as per sketch in **Fig. 1500.1**. However, the length of panel (in direction of traffic) shall not be less than the width of panel. The joints should be plugged on both the ends with pieces of synthetic tarfelt to prevent ingress of water from median/shoulder.

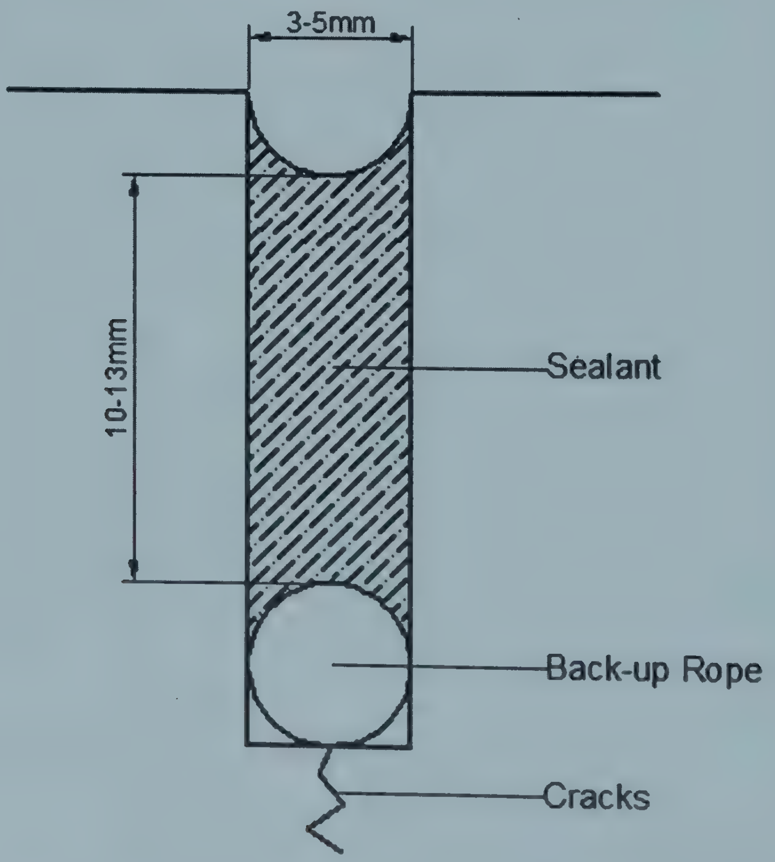


Fig. 1500.1 Contraction/Construction Joint

### 1501.8.4 *Construction joints*

Construction joints shall be placed when concreting is completed after a day's work or is suspended for more than 30 minutes. Construction joint shall be provided at the location of contraction joint. The joint shall be a butt joint. Steel bulkhead shall be used to retain the concrete while surface is finished. The joint shall be widened to 10 mm width and 20 mm depth by saw cutting to house the joint sealing material. No emergency joint shall be allowed in less than 2 m distance of any preceding or succeeding joint position. The joints should be plugged on both the ends with pieces of synthetic tarfelt to prevent ingress of water.

### 1501.8.5 *Expansion joints*

These shall be provided only near the bridges and slab culverts. The expansion joint shall consist of a bitumen impregnated joint/premoulded synthetic joint filler board about 20 mm thick complying with IS:1838 and dowel bars complying with Clause 1501.9 as specified in the drawings. The dowel bars shall be passing through the holes in the board. The filler board shall be positioned vertically along the line of the joint within the tolerances detailed in Clause 1501.2.7. The adjacent slabs shall thus be completely separated from each other by providing the joint filler board. The joints should be plugged on both the ends with pieces of synthetic tarfelt.

### 1501.8.6 *Longitudinal joints* **(Fig. 1500.2)**

The longitudinal joints shall be provided where the width of pavement is more than 4.5 metres or where ever shown on the drawings, otherwise. For a single-lane road, a longitudinal joint is not needed. The concreting in the entire width shall be done in one go and the longitudinal joint shall be saw-cut. It shall be 3-5 mm wide and of depth equal to 1/3rd the depth of the slab ± 5 mm. The joint shall be subsequently widened to a groove of 6 mm to 8 mm width and 12 mm to 15 mm depth and sealed with hot poured sealant as per Clause 1501.22 of these specifications. Before sealant is poured, a backer thread of non-combustible material such as jute thread/narial rope shall be pressed into the widened groove so as to leave unfilled depth of 8 mm to 10 mm from the top of the slab. This shall be filled with hot poured sealant as per IS:1834 upto 2 mm ± 1 mm below the surface.

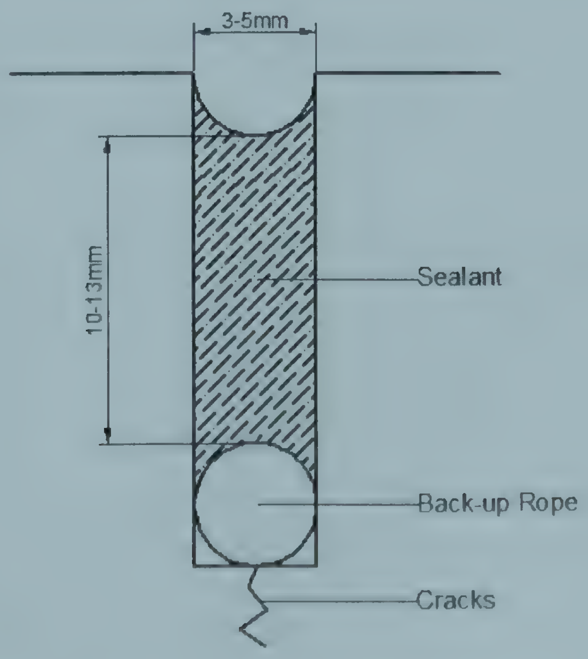


Fig. 1500.2 Longitudinal Joint

### 1501.9 Dowel Bars

Dowel bars shall be mild steel bars of 25 mm diameter and in accordance with Clause 1501.2.5 with details/dimensions as indicated in the drawings and free from oil, dirt, loose rust or scale. These shall be straight, free of irregularities and burring restricting slippage in the concrete. The sliding ends shall be sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. Normally, these shall be 500 mm long and spaced at about 300 mm centre-to-centre or as shown on the drawings.The dowel bar shall be supported on cradles/dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs.

**1501.9.1** Unless shown otherwise on the drawings, dowel bars shall be positioned at mid depth of the slab within a tolerance of ± 20 mm, and centered equally about intended lines of the joint within a tolerance of ±25 mm. These shall be aligned parallel to the finished surface of the slab and to the centre line of the carriageway and to each other within tolerances given hereunder:

i) All bars in a joint shall be within ± 5 mm in length of bar.

ii) 2/3rd of the number of bars shall be within ± 3 mm

ii) No bars shall differ in alignment from an adjoining bar by more than 5 mm in either the horizontal or vertical plane.

iv) Cradles supporting dowel bar shall not extend across the line of joint, i.e., no supporting bar of the cradle assembly shall be continuous across the joint **(Fig. 1500.1)**.

**1501.9.2** Dowel bars shall be covered by a thin plastic sheath for half the length plus 50 mm for expansion joints. The sheath shall be tightly fitting on the dowel bar. The thickness of sheath shall be not more than 0.50 mm.

**1501.9.3** A plastic sleeve, 1.25 mm thick, 100 mm length and 1-2 mm bigger in diameter closed at one end, shall be closely fitted on one end of the dowel bar. The cap shall have 20 mm thick cork/compressible sponge /thermocol synthetic plug to accommodate movement of the dowel bar due to daily/seasonal changes in temperature. The open end of the cap shall be taped to block the entry of slurry/laitance in the cap.

### 1501.10 Side Forms

All side forms shall be of mild steel channels or fabricated plates with adjustable jacks at the back and of depth equal to the thickness of pavement or slightly less to accommodate the surface irregularities of the sub-base. The forms can be placed on series of steel packing plates or shims to take care of irregularity of sub-base. These shall be sufficiently robust and rigid to support the weight and pressure caused by paving operation. The forms shall be firmly secured in position by not less than three stakes/pins for each 3 m length in straight reach and two stakes in 1.5 m – 2 m length on curves so as to prevent movement in any direction. Forms shall be straight within a tolerance of 3 mm in 3 m and when in place, shall not settle in excess of 1.5 mm in 3 m while paving is being done. The surface of the forms exposed to concrete shall be cleaned and oiled immediately before each use. The forms shall be bedded on a continuous bed of low moisture content lean cement mortar or concrete and set to the line and levels shown on the drawings within tolerances ± 10 mm and ±3 mm respectively. The bedding shall not extend under the slab and there shall be no vertical step between adjacent forms of more than 3 mm. The forms shall be got inspected from the Engineer for his approval before 12 hours on the day before the construction of the slab and shall not be removed until at least 12 hours after concreting.

At all times, sufficient forms shall be used and set to the required alignment for at least 100 m length of pavement immediately in advance of the paving operations.

### 1501.11 Construction

**1501.11.1** A method statement for construction shall be submitted by the Contractor to the Engineer for his approval. The method statement shall list all the activities and steps to be undertaken and the details of the personnel and equipment to be deployed to accomplish the task. The type and capacity of mixer, weigh batcher, arrangements for measuring of water, the procedure to mix admixtures, hauling arrangement, curing and texturing, etc. shall be specified.

**1501.11.2** *Plants, equipment and tools*

Semi-mechanised and labour oriented construction techniques will be permitted:

i) Two tilting type drum mixers of at least 0.2 cum/0.4 cum capacity with computer controlled weigh batcher for intake of materials. The number of mixers to be employed in a project shall be decided on the basis of the size of the project. One additional stand-by unit shall be kept at site.

ii) Vibrating screeds of appropriate length so that the same can be supported on the side forms for tamping and compacting pavement surface. These are moved on the levelled side forms to achieve the required smoothness, grade and surface regularity. One screed vibrator shall have straight bottom for use on super-elevation and the other one will have specified parabolic camber.

iii) A couple of needle vibrators, with one stand-by.

iv) Wooden tamper 100 mm x 100 mm x 125 mm size with mild steel shoe at bottom.

v) Concrete saw cutter for cutting initial contraction joints and subsequent widening, in a continuously constructed lane.

vi) Hand held sprayer for applying liquid curing compound with at least 10-20 litres capacity container/tank to be used where there is acute scarcity of water.

vii) Texturing brooms of steel wires brush of adequate length.

viii) one straight edge of 3 m length for routine checking, an additional master straight edge.

ix) Graduated wedge.

x) Appropriate tools for sealing joints as per IRC:57.

xi) Fixed side forms measuring at least 100-150 m length.

xii) Stop-end and start-end made of steel or wooden section.

xiii) Appropriate number of wheel barrows and iron pans.

xiv) Adequate number of spades, shovels and rakes.

xv) Drilling equipment for drilling hole in existing slab of bridge/culvert.

xvi) Pump to clean the holes/grooves of joints.

xvii) Epoxy gun for filling holes with epoxy, if any, expansion joints are needed near existing bridges/culverts.

xviii) Two sets of bulk head stop-end made of iron sheet in two halves with half diameter circular holes in each half to hold the dowel bars, and with adequate clamps to hold the assembly together.

### **1501.11.3** *Batching and mixing of materials*

All batching of materials shall be by weight. After determining the proportion of ingredients for the field mix, the fine aggregate and each separated size of coarse aggregate shall be proportioned by weight in an approved weigh-batching plant having computer control weighing attachment and placed into the hopper of the mixer along with the necessary quantity of cement. Cement shall be measured either by weight or by numbers counting each bag of 50 kg. It would be necessary to sample-check the weight of the bags occasionally. All materials other than cement shall be calculated on the basis of one or more bags (full) of cement taking the bulk weight of cement as 1440 kg/cum. Water may be measured by volume. Volume batching of aggregates may be permitted as a special case in small projects, with the approval of the Engineer.

*1501.11.3.1* If batching by volume is permitted, as a special case, separate measuring boxes shall be provided for different aggregates. The boxes shall be of strong construction provided with handles for convenient lifting and loading into the mixer. They shall be of such size that it should be possible to measure out the requisite quantity and shall be capable of being lifted by two men. Each box shall be provided with a straight edge of required length for striking off after filling. If so directed by the Engineer, improved facilities, such as, tipping boxes of accurate capacity working on run-out rails arranged for direct delivery into the hopper of the mixer shall be provided by the Contractor. In volume batching, suitable allowance shall be made for the bulking of fine aggregate due to the presence of water. For this purpose, the bulking shall be determined as per relevant Indian Standard Specification.

### **1501.11.4** *Production of concrete*

*1501.11.4.1* The concrete shall be produced near the site of placement using the concrete mixers of at least 0.2 cum capacity each. The slump of concrete shall be in the range 30 mm ± 10 mm which shall be fine tuned according to the wind velocity, ambient temperature and natural water content in coarse and fine aggregates. The mixing time shall be about one minute. In case of paving on slopes and superelevated portion, the slump will be slightly less.

*1501.11.4.2* Readymix concrete prepared as per IS:4926 and conforming to the specified properties of strength and workability shall also be permitted if the size/situation of the project so demands.

*1501.11.4.3* *Placing of concrete*

The concrete shall be placed between the formwork described hereinafter.

*1501.11.4.3.1* The concrete shall be placed between the forms separated by a distance equal to the width of the carriageway. Concrete shall be placed in a continuous manner without any break/stoppage. The concrete shall be carried to the placement location in wheel barrows and shall be levelled with shovels and rakes. It shall be prodding the form work by about 25 percent or as ascertained during field trial (Clause 1501.23) of the pavement thickness, to account for settlement during compaction. It shall be stopped at the end of day's work. It may also have to be stopped if paving remains suspended for more than ½ hour. In such a situation, stop end or bulk head will be used to retain the concrete and the joint shall be finished, as a construction joint.

*1501.11.4.3.2* *Concreting of irregular area*

Some panels will have acute angles because of some site conditions. In such situation, a bar-mat of 10 mm dia tor-steel bars at 150 mm centre-to-centre both ways shall be provided at 50 mm depth below the top of slab in the entire panel to avoid cracking of the acute angled slab.

*1501.11.4.3.3* *Concreting around man-holes*

Around man-holes, or rectangular or square openings in the road, 12 mm thick Salitex or other premoulded board as per IS:1838 shall be placed before concreting. Such panels with 'openings' shall also have bar-mats of 10 mm dia tor steel bars at 150 mm centre-to-centre both ways in the entire surface 50 mm below the top of slab.

*1501.11.4.3.4* *Paving near culverts and bridges*

i) **Hume-pipe culverts :** The pavement slab shall be carried over the hume pipe culverts ensuring adequate cushion.

ii) **New culvert/bridge :** The abutment cap shall be laid on full width of the abutment. The structural slab of culvert/bridge shall be extended over the full width of abutment cap (**Fig. 1500.3**). The structural slab shall be cast first and 25 mm dia dowel bars shall be embedded in it while casting, at 250 mm centre-to-centre or as shown on the drawings.

The exposed portion of dowel bar shall be covered with polythene sheathing as per Clause 1501.9.3. 12 mm thick, bitumen impregnated/pre-moulded synthetic filler board (IS:1838) in case of culvert and 20 mm thick board in case of bridge shall be inserted between the deck slab and pavement slab before the pavement slab is cast. Circular holes of adequate diameter shall be made in the filler board so that dowel bars pass through these holes.

The filler board shall be of full pavement width and shall be in one length. Its width shall be 20 mm less than the thickness of pavement slab. This groove shall be subsequently filled with hot poured bituminous sealant after inserting a debonding strip/rope as per drawing. Similar treatment shall be provided at the other end of the culvert/bridge. In case approach slab has been provided near the bridge, the expansion joint described as above, shall be provided between the pavement slab and the approach slab.

iii) Existing slab culvert/bridge : Expansion joint shall be provided at either end between the paving slab and culvert/bridge slab (**Fig. 1500.3**) as per clause 1501.11.4.3.4. (ii) of these Specifications. As shown in **Fig. 1500.3**, the holes will be drilled in the existing deck slab / free hand of the approach slab with a concrete drill at 250 mm centre to centre upto half depth of the dowel bar. These holes shall be 2 mm more than the dia of the dowel bar. For example, if the dowel is of 25 mm dia, the diameter of the hole will be 27 mm. The hole shall be cleaned with air jet. The dowel bars shall be fixed in these holes with epoxy rasin and shall be allowed to air cool for four hours. The exposed end of the dowel bar shall be treated as per Clause 1501.11.4.3.4 (ii) of these Specifications.

*1501.11.4.3.5* Concreting in super-elevated portions/gradients exceeding 5 percent, slump should not be more than 20 mm. To avoid slippage of fresh concrete, the paving will proceed from lower end to higher end of the pavement at gradient/superelevation.

### 1501.12 Concreting during Monsoon Months

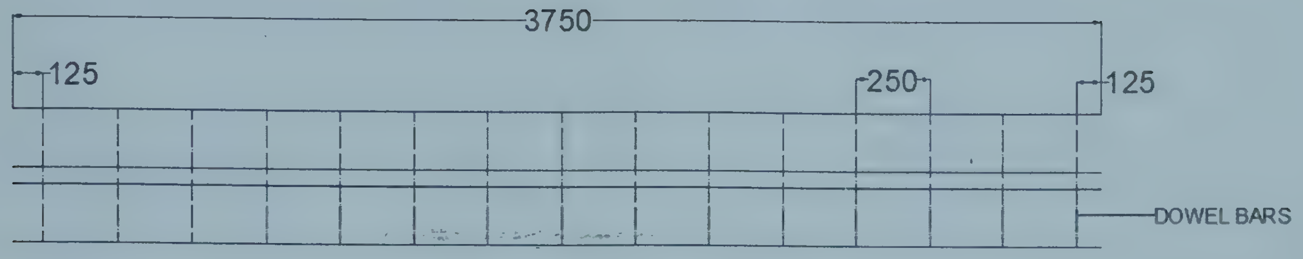
When concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulin or other water proof cloth shall be provided along the line of the work. Any time when it rains, all freshly laid concrete which had not been covered for curing purpose shall be adequately protected. Any concrete damaged by rain shall be removed and replaced. No paving work will be carried out while it is raining.

### 1501.13 Concreting in Hot Weather

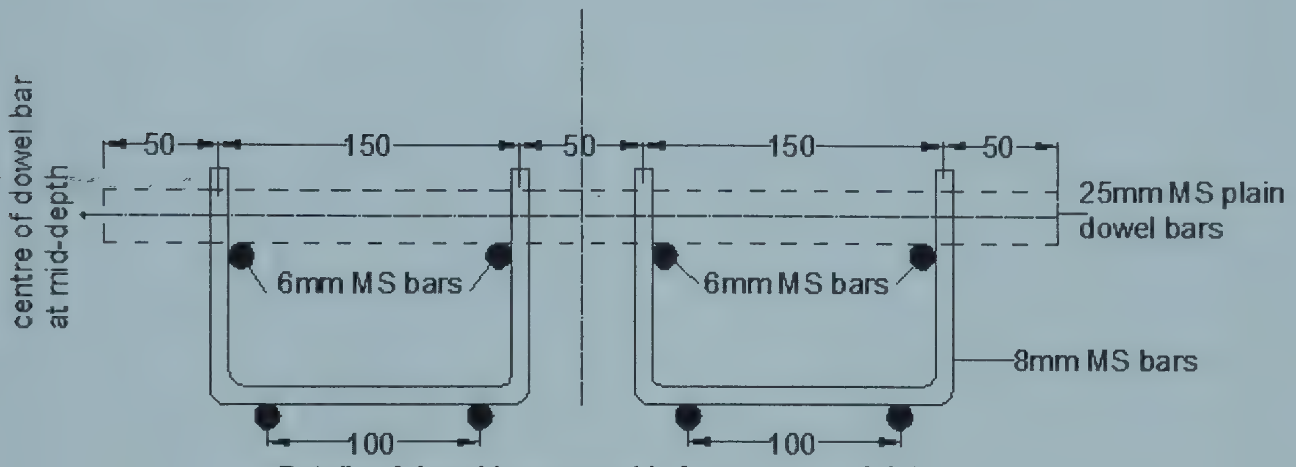
No concreting shall be done when the temperature of concrete is above 30°C measured at the point of placing, and ambient temperature is more than 35°C. Besides, in adverse conditions, like high temperature, low relative humidity, excessive wind velocity, imminence of rains, etc. freshly laid concrete shall be adequately protected by tarpaulins supported on mobile tent.

### 1501.14 Concreting in Cold Weather

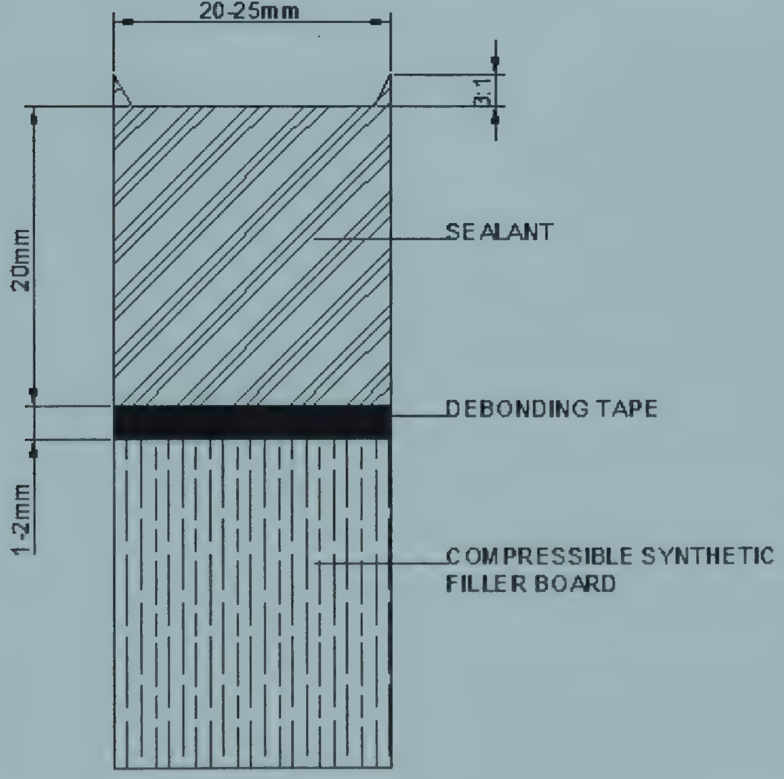
No concreting shall be done when the concrete temperature is below 5°C and the temperature is descending. The day's work shall be covered with hay so as to avoid freezing of water on the surface of the freshly laid concrete.

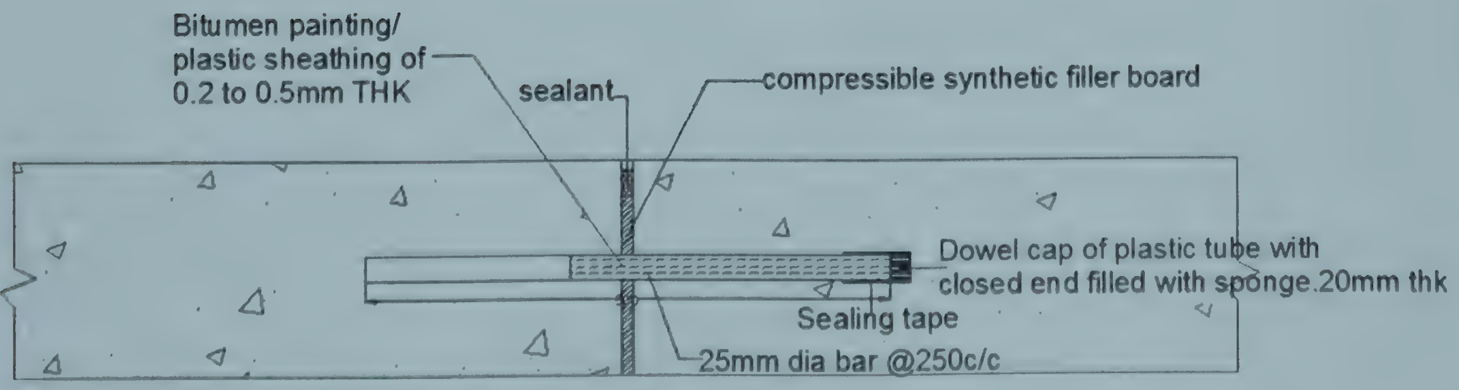

3750
125
250
125
DOWEL BARS

Top view of Transverse joint showing Dowel bars


centre of dowel bar at mid-depth
50
150
50
150
50
25mm M S plain dowel bars
6mm M S bars
6mm M S bars
8mm MS bars
100
100

Details of dowel bar assembly for contraction joint in concrete pavement for low volume roads


20-25mm
3:1
20mm
1-2mm
SEALANT
DEBONDING TAPE
COMPRESSIBLE SYNTHETIC FILLER BOARD


Bitumen painting/ plastic sheathing of 0.2 to 0.5mm THK
sealant
compressible synthetic filler board
Dowel cap of plastic tube with closed end filled with sponge.20mm thk
Sealing tape
25mm dia bar @250c/c

EXPANSION JOINT

Fig. 1500.3 Details of Joints in Concrete Pavement

### 1501.15 Compaction of Concrete

The initial compaction shall be done with a plate compactor. The final compaction of the pavement shall be accomplished by a vibrating screed. Vibrating screed shall be supplemented by portable needle vibrators. The vibrating screed shall rest on side forms. There will be two vibrating screeds. One shall be full width with straight bottom and other with bottom in specified parabolic camber. It shall be lowered vertically on to the concrete surface, evenly spread to the appropriate level above the base to provide the required surcharge for compaction; allowed to remain in position for a few seconds until compaction is complete, then lifted vertically and lowered on to the adjacent strip to uncompacted concrete. The amplitude of vibration of the screed shall be not less than 1.5 mm and the speed of travel not more than 0.6 m per minute. The screed shall again be taken slowly over the surface, sliding with its axis slightly tilted away from the direction of sliding and the operation repeated until the required dense, close knit surface is obtained. Immediately after the screeding has been completed and before the concrete has hardened, i.e., while the concrete is still in the plastic stage, the surface shall be inspected for irregularities with a profile checking template and any needed correction made by adding or removing concrete followed by further compaction and finishing. In the corners and along the side supports, needle vibrator shall also be used to ensure adequate compaction. When the screed vibrator goes out of order, the concreting shall be continued using wooden tamper at least upto next joint. The tamper may also supplement the screed vibrator if so warranted. The concrete shall be compacted within 90 minutes in summer, when temperature of concrete is between 25°C and 30°C and within 120 minutes when temperature of concrete is between 5°C and 25°C. The temperature of concrete shall be measured in wheel barrows just before placement of concrete.

### 1501.16 Floating

As soon as practicable after the concrete has been compacted, its surface shall be smoothened by longitudinal float operated from the work bridge. The float shall be worked with a sawing motion, while held in a floating position parallel to the carriageway centre line and passed gradually from one side of the pavement to the other. Movements ahead along the centre line of the carriageway shall be in successive advances of not more than one half the length of the float.

### 1501.17 Texturing

Just before the concrete becomes non-plastic, the surface shall be textured with an approved long handled steel or fibre brush conforming to the stipulations laid down in IRC:43. The brush shall be pulled gently over the surface of the pavement in transverse direction from one edge to other edge of pavement. Adjacent strokes shall be slightly overlapped. Texturing shall be perpendicular to the centre line of the pavement and so executed that the corrugations thus produced will be uniform in character and width, and about 1.5 mm deep. Texturing shall be completed before the concrete reaches such a stage that the surface is likely to be torn or unduly roughened by the operation. The textured surface shall be free from porous or rough spots, irregularities, depressions and small pockets, such as may be caused by accidentally disturbing the particles of coarse aggregates embedded near the surface. The texturing shall not be carried out when there is excessive bleeding water on the surface. The texture brush shall be cleaned to ensure that it is free from hardened cement paste/mortar. The brush shall be replaced when its wires have worn out upto about 10 mm.

### 1501.18 Curing

**1501.18.1** After completion of the finishing operations, the surface of the pavements shall be entirely covered with wet hessian cloth (minimum of two layers), burlap or jute mats. The coverings used shall be of such length (or width) that when laid, will extend at least 500 mm beyond the edges of the slab and shall be so placed that the entire surface and both the edges of the slab are completely covered. They shall be placed as soon as the concrete has set sufficiently to prevent marring of the surface. Prior to their being placed, the coverings shall be thoroughly wetted with water and placed gently with the wettest side down. They shall be so wetted down as to cause them to remain in intimate contact with the surface covered. They shall be maintained fully wetted and in position for 24 hours after the concrete has been placed, or until the concrete is sufficiently hard to be walked upon without suffering any damage. To maintain the coverings wet, water shall be gently sprayed so as to avoid damage to the fresh concrete. The concrete slab shall not be kept exposed for a period of more than half an hour for saw cutting of joints. After saw-cutting of joints, the surface shall again be covered and kept wet.

**1501.18.2** Covering shall be placed from suitable wooden/steel bridges (IRC:43). Walking on freshly laid concrete to facilitate placing coverings will not be permitted.

**1501.18.3** Upon the removal of the wet covering at the end of 24 hours, the slab shall be thoroughly wetted and then cured by ponding or sprinklers. Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal dykes of clay about 50 mm high, covered with a blanket of sandy soil free from stones, to prevent the drying up and cracking of clay. Before constructing clay dykes, the joints formed in concrete slabs shall be temporarily sealed with jute ropes, or synthetic back-up rods so that no foreign material, like, clay or sand enters the joint. The rest of the slab shall be covered with sufficient sandy soil so as to produce a blanket of earth not less than 25 mm thick after wetting. The earth covering shall be thoroughly wetted while it is being placed on the surface and against the sides of the slab and kept thoroughly saturated with water for 14 days and thoroughly wetted down during the morning of the 15th day. The sand shall not be removed and shall thereafter remain in place till 21 days from date of casting so that the concrete has attained the required strength. If at any time, the earth covering is displaced, same shall be restored and wetted.

### 1501.19 Edging

After belting and/or texturing have been completed, but before the concrete has taken its initial set, the edges of the slab shall be carefully finished so as to leave the pavement edges smooth and true to line. The floating, finishing and edging, etc. shall be done using a wooden/steel bridge with legs straddled apart so as not to touch the pavement.

### 1501.20 Joint Filling

After minimum 28 days of casting the pavement, joint groove at contraction joint which was 3-5 mm wide initially shall be widened to 10 mm width and to a depth of 18-20 mm for contraction/construction joint. For longitudinal joint, it shall be 6-8 mm wide and shall be sealed as per Clause 1501.22 of these Specifications.

### 1501.21 Debonding Strip

A 12 mm diameter jute thread/narial rope or any similar non-combustible synthetic rope material shall be forced to sit in the groove before applying the primer.

### 1501.22 Method of Sealing the Joints

#### 1501.22.1 *Cleaning the joints*

All foreign materials, if any, in the joints shall be removed with a raker. The joints shall thereafter be cleaned with a coir brush. Their fine particles clinging to the concrete faces shall be removed either with the help of an air compressor (oil free compressed air) or bicycle pump. The joints shall be cleaned and surface dried before the application of primer, so as to obtain good bond of the primer with the concrete and uniform coating of the primer thereon.

#### 1501.22.2 *Primer application*

The cleaned joint is primed with a 20-25 mm wide painter's brush. While painting, light pressure shall be applied so that the primer penetrates into the pores of concrete. The primer shall be applied in the thinnest possible complete film and then left for some time till the primer feels "tacky". The sealing compound must not be applied till the primer feels "tacky". Depending upon the weather conditions, it may take upto 2 hours for the primer to feel "tacky" during the winter and rainy seasons.

#### 1501.22.3 *Sealing compound application*

Before sealing, the temporary seal provided for blocking the ingress of dirt, soil etc. shall be removed. The compound shall be heated until it is fluid enough to pour easily into the joint. Rubberised compositions are particularly liable to be damaged by overheating, since rubber decomposes at temperature above about 180°C. If heating is not done with care, the compound may be seriously damaged. Care shall be taken to ensure that the compound is not heated above 200°C and temperature does not exceed 180°C for long periods (or other temperatures specified by the manufacturer of the compound).

#### 1501.22.4 *Pouring of sealing compound in the joint groove*

Coconut rope of slightly high diameter than the width of the groove shall be inserted in the joint groove upto a depth of about 20 mm so as to prevent leakage of any sealant into the crack. The hot sealing compound is taken out in the pouring kettle having a spout. It shall be poured into the joint opening in such a manner that the material does not spill over the exposed surface of the concrete. The pouring of the compound in the joint shall be started from the crown or the raised end of the slab. The other end(s) shall be blocked in order to prevent the sealing compound flowing out, and spill-over material shall be scraped off with a scraper, when the compound, though still warm, has somewhat hardened, but does not take any impression on being pressed with a finger. It may take about ½ hour for the compound to achieve this state of hardening. To prevent "tackiness" or "pick-up" under traffic, the exposed surfaces of the sealing compound shall be dusted with hydrated lime, if necessary. Priming or pouring of sealant into the groove needs to be avoided when the temperature of the environment is less than 7°C.

*1501.22.4.1* While the joints shall be filled to a depth of 3 mm ± 1 mm below the surface,this procedure will reduce the possibility of ingress of grit and other foreign matters into the sealing compound. To achieve this, joint shall be covered with 100 mm-150 mm wide paper strips/ any other strip so that no dust is deposited on the sealant. The covering shall remain in position for 7 days.

### 1501.23 Trial Length

**1501.23.1** The contractor shall submit for Engineer's approval a detailed method statement giving description of proposed material, plant, equipment and construction methods. The Contractor shall demonstrate the materials, plant equipment and methods of construction that are proposed for concrete paving, by first constructing a trial length of slab, off road for at least 30 m length. If the first trial is unsatisfactory, the Contractor shall have to demonstrate his capability to satisfactorily construct the pavement in subsequent trials.

**1501.23.2** The trial length shall be constructed in two parts over a period comprising of at least two separate working days, with a minimum of 15 m on each day. In manual construction, the trial length shall be constructed at a similar rate to that which is proposed for the main work.

**1501.23.3** Transverse joints and longitudinal joints of each type that are proposed for concrete slabs in the main work shall be constructed and assessed in the trial length.

**1501.23.4** Approval of the materials, plant, equipment and construction methods for main work shall be given when a trial length complies with the Specification. The Contractor shall not proceed with normal working until the trial length has been approved.

**1501.23.5** *Acceptance criteria for trial length*

*1501.23.5.1* Four full depth cores of diameter at least 100 mm (2 cores for each day's work) at 28 days will be cut by core cutting machine. The core shall be tested as per IS:516. The crushing strength of cores with height to diameter ratios between 1 and 2 may be corrected to corresponding standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation:

$$f = 0.11\,n + 0.78$$

where,

$f$ = correction factor

n = height to diameter ratio

The concrete in the work represented by the core test shall be considered acceptable if the average equivalent cube strength of the cores is at least 85 percent of the cube strength (characteristic strength) of the grade of concrete specified for corresponding age and no individual core has a strength less than 75 percent.

*1501.23.5.2* The trial length shall satisfy surface levels and regularity, and shall demonstrate that the joint-forming methodology and construction process is as per Specifications. The hardened concrete shall be cut over 3 m width and reversed to inspect the bottom surface for any segregation taking place. The trial length shall be again constructed after making necessary changes in the gradation of the mix to eliminate segregation of the mix. It shall be ensured that the lower surface shall not have honey-combing and the aggregates shall not be held loosely at the edges.

### 1501.24 Quality Control and Tolerances

The quality control, tolerances for thickness, levels and strength shall conform to the requirements of Section 1800 of these Specifications.

### 1501.25 Opening to Traffic

No vehicular traffic shall be allowed to run on the finished surface of a concrete pavement for the period as specified on the drawings and until the joints are permanently sealed and cured. In case of absolute necessity, construction traffic at a speed not more than 10 km/hour may be allowed with the written permission of the Engineer.

### 1501.26 Acceptance Criteria in Quality and Distress

Tolerance for Surface Regularity, Level, Thickness and Strength:

i) Surface Regularity: ± 6 mm in transverse direction and ± 7 mm in longitudinal direction when measured with 3 m straight edge.

ii) Tolerance Level : +5 mm and – 6 mm (upto – 8 mm at 0 to 0.3 m from the edge)

iii) Thickness : ± 10 mm

iv) Acceptance Criteria for distress/cracked slabs :

   a) The length of single crack in any panel shall be not more than 1500 mm, even though its depth is less than half of the slab depth.

   b) The cumulative length of cracks with depth of crack less than half the depth of slab in a panel shall be not more than 2000 mm.

   c) Slabs with cracks which are penetrating to more than half of the slab depth shall not be accepted. The same shall be removed and replaced by the Contractor at his cost.

### 1501.27 Measurements for Payment

Cement Concrete shall be measured in cubic metres. The volume to be paid for will be calculated on the basis of net plan area and thickness shown on the project drawings.No additional payment shall be made for extra thickness of the slab. Deficiency in thickness upto 5 mm and in not more than three panels continuously will be considered within tolerance limit and full payment will be made.

For determining thickness, a length 500 m will be considered as a 'lot'.This may be constructed even in more than 1 day. Part there of (500 m ) shall also be considered as a lot.

### 1501.28 Rate

The Contract unit rate for the construction of the cement concrete pavement shall be for carrying out the operations required for the different items of the work as per these Specifications including full compensation for all labour, tools, plant, equipments, testing and incidentals to complete the work in accordance with these Specifications, providing all materials to be incorporated in the work including construction and testing of trial length, all royalties, fees, storage, rents where necessary and all leads and lifts.

## 1502 ROLLER COMPACTED CONCRETE PAVEMENT

### 1502.1 Scope

**1502.1.1** The work shall consist of construction of roller compacted cement concrete pavement on a coarse graded granular sub-base or other drainable sub base such as no fines concrete or other medium in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the work, as approved by the Engineer. The pavement shall be constructed using semi mechanized methods.

**1502.1.2** Roller Compacted Concrete Pavement (RCCP) shall be laid as per design on granular sub-base of 75 to 100 mm thickness or as specified on the drawings and constructed to the requirements of the specification in accordance with Section 400 of these Specifications.

**1502.1.3** The design parameters such as grade of concrete, details of joints if any, width, and thickness shall be as laid down in construction drawings. However, minimum compacted thickness of Roller Compacted Concrete as wearing course shall be not less than 200 mm.

### 1502.2 Materials

**1502.2.1** *Source of materials*

The specifications as laid down in Clause 1501.2.1 shall be followed.

**1502.2.2** *Cement*

Cement shall conform to Clause 1501.2.2 of these Specifications. No flyash shall be added in pozzolana cement when fly ash is used as part replacement of cement.

### 1502.2.3 *Flyash*

Flyash used for Roller Compacted Concrete (RCC) work may be either from anthracitic coal or lignite collected by electro-static precipitator. Bottom ash or pond ash shall not be permitted as replacement of cement. Flyash for RCC shall conform to **Table 1500.2**.

**Table 1500.2 Physical Requirements of Flyash as Concrete admixture as per IS:3812 Part-I**

| S. No. | Characteristic | Requirement of Grade I Flyash |
|---|---|---|
| 1) | Fineness, specific surface area in $m^2/kg$ by Blaine's permeability test, minimum: | 320 |
| 2) | Particles retained on 45 micron IS sieve, percent maximum: | 34 |
| 3) | Lime reactivity average compressive strength in $N/mm^2$: | 4.5 |
| 4) | Soundness by autoclave test expansion of specimen in percent, maximum: | 0.8 |
| 5) | Drying shrinkage percent, maximum | 0.15 |

***Note:*** Flyash shall be mixed only in case of OPC 53 or 43 grade

### 1502.2.4 *Aggregates*

The aggregates shall conform to Clause 1501.2.4 of these specifications.

*1502.2.4.1 Coarse aggregates*

The coarse aggregates shall conform to Clause 1501.2.4.1 of these Specifications, except that the maximum size of aggregate shall be 26.5 mm instead of 31.5 mm.

*1502.2.4.2 Fine aggregates*

Fine aggregates shall conform to Clause 1501.2.4.2. of these Specifications.

*1502.2.4.3 Blending of aggregates*

The coarse and fine aggregates shall be blended so that the material after blending shall conform to the grading given in **Table 1500.3**.

### 1502.2.5 *Water*

Water shall conform to Clause 1501.2.6 of these Specifications.

### 1502.2.6 *Storage of material*

Materials shall be stored in proper places so as to prevent their deterioration or contamination by foreign matter as per Section 2000 of these specifications. If the aggregates are dusty, the same will be washed. The aggregates shall be subjected to acceptance tests prior to their use.

Cement bags shall not be placed directly on the floor and shall not touch the walls. The stack height of cement bags shall be not more than eight. The stack shall be at least 150 mm away from walls of the store room.

Table 1500.3 Aggregates Gradations for RCCP

| Sl. No. | Sieve Designation | Percentage by weight passing the Sieve |
|---|---|---|
| 1) | 26.50 mm | 100 |
| 2) | 19.0 mm | 80-100 |
| 3) | 9.50 mm | 55-75 |
| 4) | 4.75 mm | 35-60 |
| 5) | 600 micron | 10-35 |
| 6) | 75 micron | 0-5 |

### 1502.2.7 *Storage of cement*

It shall conform to Section 2000 of these Specifications.

## 1502.3 Proportioning of Materials for the Mix

### 1502.3.1 *Without flyash*

Contractor shall submit the mix design based on weighed proportion of all ingredients for approval of the Engineer 30 days prior to the trial length paving.The mix shall be proportioned by weight of all ingredients such that the desired target mean strength is achieved. The mix design shall be based on the flexural strength of concrete as per IRC:44. The moisture content shall be so selected that mix is dry enough to support the weight of a vibratory roller, and yet wet enough to permit adequate distribution of paste throughout the mass during mixing, laying and compaction operations. The water content may be in range of 5 to 7 percent by weight of total weight of coarse aggregates plus fine aggregates plus cement; dry materials required for making concrete. Trial mixes may be made with water content in the range of 5 to 7 percent at 0.5 percent intervals. The optimum moisture content which gives the maximum density shall be established. The exact moisture content requirement in the mix shall be established after making field trial construction. Using the moisture content so established, a set of six beams and six cubes shall be prepared for testing on the 7th and 28th day. If the flexural strength achieved is lower than the desired strength, the trials should be repeated after increasing the cement content till the desired strength is achieved.

### 1502.3.2 *With flyash*

The site blending when permitted by the Engineer shall be not more than 30 percent by weight of cementitious material. The flyash concrete shall have zero slump. The modified Proctor compaction test can be used for determining the optimum moisture content (OMC) for compaction. Rest of the specifications shall conform to Clause 1502.3.1. When Portland Pozzolana Cement flyash based, as per IS:1489 (Part 1) or any other blended cement is used, flyash shall not be used as replacement of cement.

All other Clauses of these Specifications shall also apply.

**1502.3.3** The water content shall be between 5 percent to 7 percent by weight of the total dry weight of coarse aggregate plus fine aggregate plus cement. The correct amount of water to be added in the mix, shall be adjusted during trial length construction so as to achieve rollable consistency. While executing the job; if transportation of mix by tippers is essential, then water content shall be kept upto 2 percent higher than optimum moisture content to account for evaporation losses, and to render the compaction of Roller Compacted Concrete a closed and cohesive pavement slab.

#### 1502.3.4 *Cement content*

The minimum cement content in the Roller Compacted Concrete mix for pavement shall be not less than 350 kg per cum of concrete. If the designated or characteristic compressive strength of 30 MPa at 28 days is not achievable with the minimum quantity of cement, the same shall be increased in suitable installments. For this no additional payment shall be made to the Contractor. The quantity of cement shall not exceed 425 kg per cum of concrete. If flyash is used to replace a part of cement in the concrete mix, the cement content shall be not less than 270 kg per cum.

#### 1502.3.5 *Design*

The mix design shall be based upon flexural strength which shall be not less than 3.8 MPa. The design mix shall be minimum of M30 grade also.

#### 1502.3.6 *Concrete strength*

Average compressive strength of each consecutive group of 5 cubes shall be not less than 30 MPa at 28 days. Considering the variations in field, the laboratory mix shall be designed for at least 1.25 times the required 28 days field strength. The flexural strength $f_f = 0.7 \sqrt{f_{ck}}$.

where $f_{ck}$ is characteristic compressive cube strength in MPa

### 1502.4 Construction

The construction of Roller Compacted Concrete Pavement shall be attained as laid down in these Specifications, overlaid on sub-base, duly compacted and finished.

#### 1502.4.1 *Sub-base*

It shall conform to Clause 1501.6.1. of these Specifications.

#### 1502.4.2 *Batching and mixing*

The specifications as laid down in Clauses 1501.11.3. and 1501.11.3.1. shall be followed. A concrete mixer with computer control weigh batching system will be installed at site. The weighed quantities of the ingredients, i.e., coarse aggregates, flyash when used, sand and cement shall be discharged in the mixer drum and shall be mixed for not less than 1.5 minutes for a batch. When ready mix concrete is used, the guidance for Ready mixed concrete shall be taken from IS:4926. The mixer shall be minimum of full bag capacity (0.2 cum). When sufficient confidence has been gained, volume batching may be permitted in writing by the

Engineer. The wooden or iron measuring boxes only shall be used to measure the ingredients by volume. Extra wooden strips (phatties) shall be added to measure the quantities of coarse and fine aggregates. However, in case of cement, only steel measuring box will be used. Similarly, in case of water, a permanent mark will be made on a suitable container to allow only the specified quantity of water.

In case of aggregates, the weighting accuracy shall be ± 2 percent by weight and for cement flyash and water, it shall be ± 1 percent.

*1502.4.2.1* The loading sequence of ingredients in the mixer drum shall be coarse aggregates, fine aggregates, cement and lastly water.

### **1502.4.3** *Production*

The concrete shall be produced near the site of placement using concrete mixers of at least 0.2 cum capacity. Higher capacity concrete mixer will be preferred.The concrete shall be 'zero slump' concrete. The mixing time shall not be less than 1.5 minutes.

### **1502.4.4** *Transportation*

The mixed material shall be transported in wheel barrows or steel pans. For larger works, it will be desirable to use tippers/transit mixers for transporting of mix. The tippers, if used, shall be covered with tarpaulin to avoid loss of moisture by evaporation.

#### *1502.4.4.1* *Side forms*

The side forms shall be fixed as per Clause 1501.10 of these Specifications and shall be as per IRC:43.

### **1502.4.5** *Placing of roller compacted concrete*

The concrete shall be placed between the forms separated by distance equal to the width of carriageway in a continuous manner without any break.

#### *1502.4.5.1* *Placing by semi-mechanized tools*

At about every six metres, camber templates or unidirectional tapered templates having 2 percent camber/slope shall be positioned. In between, thickness blocks with 25 percent to 30 percent ruffle shall be placed between the camber templates. The actual prodding shall be ascertained during field trial. The mix shall be placed with wheel barrows/steel pans with rotary motions and it shall be spread uniformly with the help of shovels and rakes. A wooden screed (wooden batten 125 mm x 50 mm and about 3 m long)shall be used in a sawing motion to level the mix before rolling. Any deficiency in thickness shall be made good by racking the surface and adding fresh concrete. Once the loose Roller Compacted Concrete has been placed in first compartment, rolling shall commence immediately. Uniform spreading is very important from the consideration of getting uniformity in density, compaction and finally uniform designed thickness. The concreting shall be stopped only at the end of the days work. It may also have to be stopped if paving remains suspended due to unavoidable circumstances for more than ½ hour. The concrete shall be tapered in ½ m length while stopping the paving. Before commencement of paving on next day, this half metre shall be cut straight and fresh, concrete shall be abutting the old concrete. Alternatively, at the end of days work tapered wooden block head (at 30° angle) abutting vertically in the transverse direction may be placed to avoid wastage of half metre length of RCC. Additional compaction with plate compactor will be done at terminal end.The exposed sides of pavement shall be finished with 1:4 cement sand mortar to prevent ingress of water from shoulders.

### *1502.4.5.2 Placing by mechanical paver*

The placing of concrete by mechanical paver shall be permitted. The equipment shall be capable of laying the material in one layer in full width in an even manner without segregation so that after compaction, the total thickness achieved is as specified. The paver shall have high amplitude tamping bars to give good initial compaction to the concrete. When paving is done by paver, the pavement width shall be 300 mm extra on either side. In that case, no side forms are needed.

### **1502.4.6** *Rolling and compacting*

The zero slump Concrete shall be rolled with a tandem vibratory roller of 80 to 100 kN static weight as given in **Table 1500.4**. Alternatively, it can also be rolled with a soil compactor with front single wheel of steel drum and rubber tyred wheels at the rear. The first pass shall be in static mode. In 3rd and 4th pass, amplitude will be kept high and then reduced gradually to the minimum in the subsequent passes. The last two passes will be in static mode to remove any roller marks.

*1502.4.6.1* At the end of rolling, no roller marks shall be visible. The rolling shall commence from lower edge(s) to centre/super elevated edge. The speed of roller shall not exceed 4 km per hour.

**Table 1500.4 Rolling Sequence, Number of Passes Based on Type of Roller**

| S. No. | Type of Roller | Number of Static Passes | Number of Vibrating Passes | Remarks |
|---|---|---|---|---|
| 1) | Double drum tandem roller | 2<br>Nil<br>1-2 | Nil<br>4 - 6<br>Nil | Breakdown rolling<br>Vibratory rolling with amplitude 0.8-0.4 mm<br>Smoothening |
| | | | | Or |
| 2) | Single front drum steel roller with rear tyres of rubber | 1<br>Nil<br>1-2 | Nil<br>4 - 5<br>Nil | Breakdown rolling<br>Vibratory rolling with amplitude descending from 1.8 mm to 0.4 mm<br>Smoothening |

*1502.4.6.2* If some hungry surface or honey combed concrete is visible after rolling, moist cement sand mortar 1:4 shall be broomed-in and one pass of roller in static mode shall be given.

*1502.4.6.3* The in-situ-density by sand replacement method shall be checked and if the field density is less than 97 percent density of achieved in trial length, additional passes of roller shall be given to achieve minimum 97 percent of the density of trial length, without any delay.

*1502.4.6.4* The surface unevenness shall be simultaneously checked with 3 m straight edge and high spots shall be raked open, extra material removed and recompacted. If the thickness is less, even then the area shall be raked open, extra material added and recompacted by roller without any delay. No roller marks, lines or loose material shall be left out. No attempt shall be made to fill up the depressions by depositing fine material.

*1502.4.6.5* When next day's work will commence, the Roller Compacted Concrete in a width of 0.3 m or more where full thickness is available from terminal end, shall be either saw cut as a butt joint or on removing wooden form or bulk head. Voids, if any, shall be filled with 1:4 cement sand mortar. The cut material shall not be used in Roller Compacted Concrete and shall be thrown away. The initial length of about 2-3 m shall be compacted by running the roller in transverse direction so as to save the previous day's vertical end intact. After this,compaction roller shall work in usual longitudinal direction.

*1502.4.6.6* The final time of rolling of the Roller Compacted Concrete shall not exceed 90 minutes from time of mixing water when the concrete temperature is between 25°C and 30°C. Similarly, it shall not exceed 120 minutes when the same is less than 25°C or equal to 25°C. No concreting shall be done when ambient temperature is less then 4°C and descending or more than 35°C. Chilled water or ice shall be added to mixing water to bring down the temperature of concrete upto 30°C in summer if needed.

When ambient temperature is below 5°C or more than 35°C,necessary precautions for laying and placing of concrete shall be as under.

a) The following precautions should be taken when ambient temperature goes beyond 35°C.
    i) Further concreting should be stopped.
    ii) 53 grade cement should not be used alone.
    iii) The aggregates should be kept under shade and water may be sprinkled to keep them cool.
    iv) The concrete mixer should be painted white on the outer side to inhibit absorption of heat from the sun and air.
    v) The form work should be kept covered with wet sand and wet earth.
    vi) Immediately after consolidation and surface finish, the pavement should be covered by mobile tents and wet gunny bags.

b) When ambient temperature is below 5°C
    i) when concrete is likely to be subjected to freezing, the use of air entraining agent is mandatory. The air content in the concrete shall be 4 ± 1.5 percent.

ii) If there is compulsion to do the concreting in temperature below 4°C, the aggregates water should be heated.

iii) The concrete slab immediately covered with mobile tents and hot air be circulated and temperature of the enclosed air should be raised to 15°C.

#### *1502.4.6.7 Paving near culverts/bridges*

The Roller Compacted Concrete shall be carried over the hume pipe culverts. In all other cases, when slab culverts or bridges are provided or are existing, it shall abutt the deck slab of the culvert or approach slab/deck slab of the bridge and a construction joint shall be formed in accordance with Clause 1502.5. Additional layer of 200 mm thick non plastic GSB shall be provided over the sub-base in full panel length and full carriageway width as per drawings. Plate vibrator shall be used for adequate compaction near the abutment or at locations where roller cannot compact the layers efficiently.

### 1502.5 Joints

No longitudinal joint shall be provided if the width of carriageway is less than 3.75 m i.e. one lane. In 5.5 m wide intermediate lane, longitudinal joint will be provided at 2.75 m (mid line of the carriageway). Roller Compacted Concrete Pavement (RCCP) shall have only transverse contraction joints at 4 m centre-to-centre. These shall be saw-cut after 24 hours of laying depending upon weather. As the joints are filled after curing period is over, i.e., 14 days, to avoid infiltrates of foreign particles, i.e., aggregates or dust into the joints, flexible synthetic rope or jute rope may be placed inserted in the empty joints. The width shall be 6-8 mm and depth 1/4th of Roller Compacted Concrete slab thickness. These shall be filled with hot poured sealing compound as per Clause 1501.22 of these Specifications and in accordance with IS:1834. The joint at the end of the days work or emergency joint due to stopping of work more than ½ hour shall be butt joint and sealed as above.

### 1502.6 Curing

Soon after the compaction is over depending upon the weather, wind velocity and humidity, curing shall start within one hour to two hours, after laying by covering the Roller Compacted Concrete Pavement with wet hessian in two-three layers for first 24 hours. After the first day's curing, small earthen rectangles/dykes about 50 mm high transversely and longitudinally shall be made and shall be filled with water for at least 14 more days. In case of flyash admixed concrete, curing may be extended upto 16 days.

### 1502.7 Protection of Concrete

The freshly laid concrete shall be protected by means of suitable barricades to prevent traffic for first 28 days at least.

### 1502.8 Trial Mix

Trial mixes of RCCP shall be prepared using cement aggregate ratio as constant and water content as 5 percent, 5.5 percent, 6 percent, 6.5 percent and 7 percent of mix by weight.

Optimum moisture and density shall be established by preparing cubes with varying moisture contents. Compaction of the mix in 150 mm cube moulds shall be done in three layers with vibrating hammer fitted with a square or oblong foot or through loaded plate vibrator of size just smaller than 150 mm. After establishing optimum moisture by moisture density curve 6 no. cubes shall be cast at Optimum Moisture Content, (OMC) and these shall be tested for strength after 3 days and 7 days of casting. If the compressive strength is less than specified strength, the process shall be repeated by adding more cement, by the contractor at his own cost.

### 1502.9 Trial Length

**1502.9.1** The trial length shall be near the main road. For reasons of economy, trial length may form part of driveway for buses near bus shelter or may be additional lane near bus stops or for parking. This shall be done after approval of the Engineer. No payment shall be made for trial length and its construction shall be incidental to the main work.

**1502.9.2** The Contractor shall submit methodology and mix design report for carrying out the work 30 days before trial length is to be laid. The trial length shall be laid at least two weeks before the main pavement is to be constructed. The trial length shall be normally not less than 30 m in length. It shall involve at least two working days so that treatment at end of day's work/start of day's work is supervised. The trial length shall be rolled as per rolling sequence given in **Table 1500.4**. If during compaction of trial length, waves appear on the top of rolled surface in front of the roller, the mix in that case shall tender. If the mix is not cohesive and is segregated, it is too harsh.The moisture content shall be varied and strength re-determined. Before production of mix, natural moisture content of aggregates should be determined on day to day basis so that only designed moisture content could be used to prepare the mix.

**1502.9.3** After rolling, the in-situ density of freshly laid Roller Compacted Concrete layer shall be checked by sand replacement method with 200 mm dia density hole. Three density holes shall be made along a diagonal which bisects the trial length taking care that no holes are made within 0.5 metre of edge from either side. The average density of these three- holes shall be taken as reference density and taken as 100 percent. Later on, the field density of regular work shall not be less than 97 percent of this reference density.

**1502.9.4** The trial length shall be cut over one metre length and reversed to inspect the condition of concrete at the bottom. It should not be segregated. The trial length which does not comply with these specifications shall be removed and relaid. The main work shall start only after approval of trial length by the Engineer.

**1502.9.5** Core density shall be taken after 28 days age of concrete. The homogeneity of Roller Compacted Concrete layer shall also be assessed from the cores. A minimum of three cores shall be taken from each day's trial work. The average of three cores for the day shall be the core density for day's work.

The strength of cores shall be governed by Clause 1501.23.5.1 of these Specifications.

### 1502.10 Quality Control and Tolerances

The quality control, tolerances for thickness, levels and strength shall conform to the requirements of Section 1800 of these Specifications.

### 1502.11 Acceptance Criteria for Cracked Concrete Slabs

i) The length of single crack in any panel shall be not more than 1500 mm, even though its depth is less than half of the slab depth.

ii) The cumulative length of cracks with depth of crack less than half the depth of slab in a panel shall be not more than 2000 mm.

iii) Slabs with cracks which are penetrating to more than half of the slab depth shall not be accepted.

### 1502.12 Opening to Traffic

No commercial traffic, i.e., buses, trucks and tractors with or without trolleys are to be allowed on Roller Compacted Concrete Pavement for a period as specified in the drawings and until the joints are sealed. However, very light construction traffic may be allowed at very slow speed (not more than 4 km per hour) with written permission of the Engineer only after 7 days of laying.

### 1502.13 Measurements for Payment

The unit of measurements for Roller Compacted Concrete Pavement shall be in cubic metres. This shall be based upon built-up area of cross-section and depth indicated therein. The extra width on either side, beyond approved cross-section shall be incidental to the item and shall not be measured and paid for. No payment shall be made for extra thickness of the pavement. Deficiency in thickness upto 5 mm and in not more than three panels continuously will be considered within tolerance limit and full payment shall be made. For determining thickness, a length of 500 m will be considered as a lot. This may be constructed even in more than one day. Part thereof (500 m) shall also be considered a lot.

### 1502.14 Rate

The contract unit rate payable for Roller Compacted Concrete Pavement shall be payment in full for carrying out the work including labour, material, machinery working charges, curing, royalties, octroi and incidentals such as cost of running various tests and construction and tests of trial length, etc. to deliver the product as per laid down Specifications.

## 1503 RECTANGULAR CONCRETE BLOCK PAVEMENT

### 1503.1 Scope

**1503.1.1** The rectangular concrete block pavement (CBP) shall consist of a surface layer of appropriate-sized concrete block paved on a thin, compacted sand bedding layer of specified grading, which is spread over a properly profiled base course and is bounded by edge restraints. The joints shall be filled by fine sand of specified grading. The work shall include furnishing of all plant and equipment, material and labour for manufacturing and laying concrete blocks in position and performing all other operations in connection with the work as approved by the Engineer. Only mechanized or semi-mechanized methods of manufacturing cement concrete blocks shall be acceptable.

**1503.1.2** The design details, viz., dimensions of blocks, grade of cement concrete, joint details, patterns of laying and end restraints, etc. shall be as shown on the drawings. The thickness of block shall not be less than 150 mm and grade of concrete shall not be less than M30.

## 1503.2 Materials

### 1503.2.1 *Source of materials*

Clause 1501.2.1 of these Specifications shall be followed.

### 1503.2.2 *Cement*

Cement shall conform to Clause 1501.2.2. of these Specifications.

### 1503.2.3 *Aggregates*

The aggregates shall conform to Clause 1501.2.4.

### *1503.2.3.1 Course aggregates*

The course aggregates for manufacture of blocks shall conform to Clauses 1501.2.4.1 and 1501.2.4.1.1 of these Specifications.

### *1503.2.3.2 Fine aggregates*

The fine aggregates far manufacture of blocks shall conform to Clause 1501.2.4.2.

### *1503.2.3.3 Admixtures*

Admixtures, if used for attaining required workability of concrete mix shall conform to IS:9103.

### 1503.2.4 *Water*

Water shall conform to Clause 1501.2.6 and **Table 1500.2**.

### 1503.2.5 *Aggregate gradation*

The aggregate gradation shall conform to **Table 1500.1** of these Specifications.

### 1503.2.6 *Joint filling sand*

The joint filling sand shall be fine sand conforming to grading as per **Table 1500.5**.

### 1503.2.7 *Bedding sand*

It shall conform to grading specified in **Table 1500.5**.

**Table 1500.5 Recommended Grading for Bedding and Joint Filling Sand**

| IS Sieve Size | Percent Passing | |
|---|---|---|
| | **Bedding Sand** | **Joint Filling Sand** |
| 10.00 mm | 100 | 100 |
| 4.75 mm | 90-100 | 95-100 |
| 2.36 mm | 75-100 | 95-100 |
| 1.18 mm | 55-90 | 90-100 |
| 600 micron | 35-59 | 80-100 |
| 300 micron | 8-30 | 15-50 |
| 150 micron | 0-10 | 0-15 |
| 75 micron | 0-3 | 0-5 |

**1503.2.8** *Storage of materials*

This shall conform to Section 2000 of these Specifications.

*1503.2.8.1* *Storage of cement*

It shall conform to Section 2000 of these Specifications.

### 1503.3 Size of Paving Blocks

The size of paving blocks and restraint blocks shall be 450 mm x 300 mm x 150 mm (length × width × thickness). If any other size is adopted as per drawings or as per directions of the Engineer, the width to length ratio shall not be more than 1:5.

### 1503.4 Mix Design

**1503.4.1** The concrete for block pavements shall have design mix of M30 grade. The laboratory trials on the mix design shall be made by the Contractor and the mix design submitted to the Engineer for approval 30 days prior to the paving of trial length. The mix design shall be tested for characteristic strength in compression by 150 mm x 150 mm x 150 mm cubes cured for 28 days. The design of concrete mix shall be as per guidelines given in IRC:44 or IS:10262. The aggregates cement ratio shall normally be in the range of 3:1 to 6:1.

*1503.4.1.1* If necessary the quantities of coarse or fine aggregates in gradation of the aggregates may be varied to achieve the minimum characteristic strength.

**1503.4.2** *Cement content*

The cement content shall be not less than 350 kg/cum. nor shall it be more than 425 kg per cum. However, if the Contractor is not able to achieve the specified characteristic strength with 350 kg/cum increase the quantity of cement accordingly. He shall not be paid any extra cost for using the additional cement.

#### 1503.4.3 *Concrete strength*

The characteristic compressive strength of concrete shall be not less than 30 MPa.

### 1503.5 Workability

The total water content shall be between 5-7 percent by weight of total dry materials (cement + sand + coarse aggregates). When blocks are manufactured using block making machine, the concrete shall be "Zero slump concrete". When concrete blocks are manufactured using vibrating table along with surface vibrator, the concrete slump may vary from 10-15 mm.

### 1503.6 Manufacture and Curing of Blocks

**1503.6.1** The blocks shall preferably be manufactured with the help of block manufacturing machine. If the same is not available, the blocks shall be manufactured with the help of semi-mechanised means, i.e., vibrating table and a surface vibrator. Thorough vibration will be imparted for proper compaction. Tough plastic moulds or steel moulds shall be used for the purpose. The sides and bottom of moulds shall be oiled with shuttering oil prior to filling of mould. The moulds shall be removed at appropriate time varying from 12-24 hours of casting of blocks and then the blocks shall be cured in water tank for 28 days. The moulds shall be washed with water after each use and oiled before each re-use.

#### 1503.6.2 *Buffer*

Extra number of blocks to the extent of 5 percent shall be manufactured at the time of initially casting the blocks and shall be properly stored for replacement as and when needed.

### 1503.7 Subgrade

The subgrade shall conform to Clause 1501.5.1 of these Specifications and shall have camber of 3 percent. When the soaked CBR of subgrade soil is less than 4 percent, it shall be improved by cement/lime/lime-flyash/mechanical stabilization as appropriate or 300 mm thick existing layer shall be replaced with soil of minimum CBR of 4 percent as provided in the Contract or directed by the Engineer. The improved CBR of stabilized soil shall be not less than 10 percent.

### 1503.8 Sub-base

The sub-base shall be 100 mm thick Granular Sub-Base (GSB) or 100 mm thick WBM using Gr. 1 metal conforming to Section 400 of these Specifications. In case the subgrade soil is clayey, the sub-base shall be extended over the full formation width for proper drainage.

### 1503.9 Shoulders

Earthen Shoulders of minimum 1.00 m width on either side shall be prepared with camber of 4 percent.

### 1503.10 Base Course

The base course shall be 75 mm thick WBM Gr. 2 or Gr. 3 conforming to Section 400 of these Specifications. The base course shall be extended by at least 150 mm beyond edge blocks.

### 1503.11 Bedding Sand

Bedding sand conforming to grading given in **Table 1500.5** shall be uniformly laid over the base course to a compacted thickness of 25 mm to 30 mm. It shall be profiled truly to the camber or unidirectional fall on superelevations, with the help of a screed. The screed can be guided to proper level by tensioned string lines set above the base course or by thickness blocks. The bedding sand shall have about 6 percent moisture to facilitate its spreading and compaction. Screeding shall not be processed beyond about 1 metre ahead of‘ the planned end of the block paving for the day. Sand shall be compacted with a hand rammer or plate compactor and level shall be re-adjusted, if needed, by using the screed.

### 1503.12 Laying of Blocks

The pattern for paving of blocks shall be stretcher as shown in **Fig. 1500.4**. The joints shall be staggered. The joint between any two stretchers shall be staggered by about half the length of the stretcher. The edge restraining blocks shall be placed on end on edging end made to stand vertically so that their outer/inner edge matches with the profile of block pavement. Control over alignment, laying pattern and joint width can be assisted by the use of chalked string lines set at about 5 m intervals.

### 1503.12.1 *Joints*

The width of joint shall be between 4 mm to 6 mm on curves, non-unifrom joint width may have to be resorted to. Cutting paving blocks for filling the paving gaps occurring against edge restraints, etc. shall be deferred until sufficient work has progressed to allow reasonably continuous operation. When space does not permit the use of cut piece of blocks, the use of premixed or dry packed concrete is recommended. After a section has been paved, compaction with a vibratory plate compactor shall be done in the following sequence of operations.

i) The blocks shall be vibrated with three passes of a standard vibrating plate compactor of weight 0.9 kN, plate area not less than 0.3 square metres and capable of applying centrifugal force of 15 kN.

ii) A thin layer of joint filling sand as per Clause 1503.2.6 shall be spread on the top of paved blocks and swept into joints using suitable brooms.

iii) The sand shall be vibrated into the joints by moving the vibrating plate compactor and more sand shall be applied till the joints are well packed.

iv) Excess sand from the top of block pavement shall be swept clean and disposed of.

### 1503.13 Acceptance Criteria

Minimum six cubes per day's work (3 each for 7 day and 28 day strength) shall be cast, cured and tested as per IS:516.

The compressive strength shall not be less than $f_{ck}$ + 3 MPa where $f_{ck}$ is the design characteristic compressive strength.

### 1503.14 Trial Length

The Contractor shall lay a trial length of 30 m before proceeding with the main work. The same shall be got approved from the Engineer before proceeding with the regular pavement. The length shall be rectified/re-laid, if, found deficient in Specifications. The procedure demonstrated in the laying of trial length shall be followed while laying the main pavement.

### 1503.15 Opening to Traffic

The pavement may be opened to traffic soon after completion of a stretch.

### 1503.16 Tolerance

#### 1503.16.1 *Level tolerance*

The tolerance in surface levels shall be not more than ± 15 mm.

#### 1503.16.2 *Surface regularity*

The maximum allowable difference between the road surface and underside of a 3 m straight edge when placed parallel or at right angles to the centre-line of the road at points decided by the Engineer shall be as under:

Longitudinal profile : not more than 12 mm
Cross profile : not more than 10 mm

### 1503.17 Measurements for Payment

The measurement shall be in square metres measured from outer edge of restraint block to outer edge of restraint block across the whole width of pavement.

### 1503.18 Rate

The contract unit rate shall include cost of manufacture of blocks, including materials, cost of curing, stacking, transportation to site, laying of block, including supplying and applying bedding sand and joints filling sand including full compensation for labour, tools, plant, equipment, testing and all incidentals to the work complete as per Specifications including construction of trial length, all royalties, taxes, storage rents whereever necessary and all leads and lifts.

## 1504 INTERLOCKING CONCRETE BLOCK PAVEMENT

### 1504.1 Scope

Interlocking Concrete Block Pavement (ICBP) shall consist of a surface layer of appropriate sized concrete paving blocks paved and compacted over a thin bedding sand layer of specified grading, which is spread over a properly constructed and profiled base course and is bounded by properly installed edge restraints. The joints shall be filled by fine sand of specified grading. The work shall include supplying laying and paving of blocks including all materials, labour and equipment and performing all operations in connection with the laying of ICBP as per these Specifications.

### 1504.2 Materials

**1504.2.1** The Concrete Paving Block shall conform to the relevant IS standard.

**1504.2.2** *Bedding sand*

Bedding sand shall conform to the grading given in **Table 1500.6**.

**1504.2.3** *Joint filling sand*

Joint filling sand shall conform to grading given in Table 1500.6.

**Table 1500.6 Gradings for bedding and joint filling sand**

| IS Sieve Size | Percent Passing | |
|---|---|---|
| | For Bedding Sand | For Joint Filling Sand |
| 10.00 mm | 100 | 100 |
| 4.75 mm | 90-100 | 90-100 |
| 2.36 mm | 60-95 | 75-100 |
| 1.18 mm | 15-34 | 55-90 |
| 600 micron | 25-60 | 35-59 |
| 300 micron | 5-20 | 8-30 |
| 150 micon | 0-10 | 0-10 |
| 75 micron | 0-5 | 0-5 |

### 1504.3 Buffer

Buffer of specified quantity of paving blocks (of the same shape, size and thickness) required for normal maintenance of paved area as specified by the Engineer, shall be supplied and stored for replacement as and when needed. Normally this will be 5 percent of the blocks used in the paved area.

### 1504.4 Block Thickness

For rural roads catering to heavy vehicles, the minimum thickness of paving blocks shall be

60 mm for traffic up to 100 vehicles per day, and 80 mm for projected traffic from 100 to 250 vehicles per day. Two wheelers shall not be counted in traffic census.

### 1504.5 Dimensions and Tolerances

The dimensions and tolerances of paving blocks shall conform to the Specifications given in **Table 1500.7**. Aspect ratio is the ratio of length to thickness of blocks. Chamfer is the bevelled edge, provided on the top surface of a block. Plan area is the horizontal area bounded by the vertical faces. Wearing surface area is the horizontal area bounded by the vertical faces, of the edge blocks minus the area reduced due to the presence of chamfer.

**Table 1500.7 Dimensions and tolerances for paving blocks**

| S. No. | Dimension | Recommended Values | Tolerance Limit |
|---|---|---|---|
| 1) | Width W | To be specified by Manufacturer | ± 2 mm |
| 2) | Length L | To be Specified by Manufacturer | ± 2 mm |
| 3) | Thickness T | 60 to 80 mm | ± 3 mm |
| 4) | Aspect Ratio L/T | Maximum : 4.0 | + 0.2 |
| 5) | Chamfer (Arris) | Minimum : 5 mm<br>Maximum: 7 mm | ± 1 mm |
| 6) | Plan Area | Maximum : 0.03 m$^2$ | + 0.001 m$^2$ |
| 7) | Wearing Face Area | Minimum 75% of Plan Area | - 1% |
| 8) | Squareness | NIL | ± 2 mm |

### 1504.6 Compressive Strength

**1504.6.1** The average 28 days compressive strength of 8 blocks shall be 30 MPa and strength of individual block shall be not less than 26 MPa.

**1504.6.2** The 28 days compressive strength of paving blocks tested as per relevant IS specification shall be determined as explained hereinafter.

*1504.6.2.1* Compression testing machine of adequate capacity shall be used for testing of blocks. The steel bearing plates shall have a minimum thickness of 25 mm. The surface area of the bearing side of the plate should be such that no edge of the bearing plate is less than 10 mm from the outer edge of the paving block being tested.

*1504.6.2.2* In case the testing surface of the paving block departs from a plain surface by more than 0.05 mm, capping using suitable materials shall be adopted for testing as per IS:516.

*1504.6.2.3* The blocks shall be stored for 24 ± 4 hours in water maintained at a temperature of (20± 5)°C before testing. The dimensions and plan areas of the block shall be determined. The bearing plates of the testing machine shall be wiped clean. The specimen shall be clamped between the plates in such a way that the axes of the specimen are vertically aligned with those of the bearing plates.

*1504.6.2.4* The load shall be applied without shock and increased continuously at a rate of 15± 3 N/mm²/minute until no greater load can be sustained by the specimen or delamination occurs. The maximum load applied to the specimen shall be noted.

*1504.6.2.5* The apparent compressive strength of individual block shall be calculated by dividing the maximum load (N) by the plan area (mm²). The corrected compressive strength shall be calculated by multiplying the apparent compressive strength by the appropriate correction factor from **Table 1500.8**. The strength shall be expressed to the nearest 0.1N/mm².

**Table 1500.8 Correction Factors for Thickness and Chamfer of Paving Block for Calculation of Compressive Strength**

| Paving Block Thickness (mm) | Correction Factor for | |
|---|---|---|
| | Plain Block | Chamfered Block |
| 60 | 1.00 | 1.06 |
| 80 | 1.12 | 1.18 |

*1504.6.2.6* *Water absorption*

The water absorption being the average of five blocks shall be not more than 6 percent by mass.

### 1504.7 Edge Blocks

The edge blocks shall have equivalent cube compressive strength not less than 30 MPa. The road kerbs provided on the edges of the road also serve the purpose of edge blocks. In case the end kerbs are not provided, 300 mm x 300 mm x 150 mm of M30 grade concrete edge blocks or other suitable size as per drawings or direction of the Engineer shall be provided.

**1504.7.1** *Subgrade*

The Subgrade shall conform to Clause 1501.5.1 of these Specifications. The soaked CBR of subgrade soil shall be not less than 4 percent.

### 1504.8 Sub-base

The sub-base shall be 100 mm thick granular layer 100 mm thick or WBM Gr.1 conforming to Section 400 of these Specifications. In case the subgrade soil is clayey, the sub-base shall be extended over the full formation width for proper drainage.

### 1504.9 Base Course

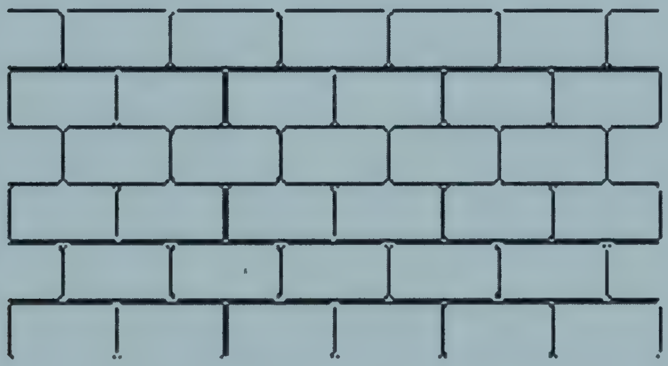
A minimum 100 mm thick layer of granular/stabilized base course shall be provided. The base course layer shall be extended at least 300 mm beyond the edge restraints. The material shall conform to Section 400 of these Specifications.

### 1504.10 Bedding Sand

Bedding sand conforming to **Table 1500.6** shall be uniformly laid to a compacted thickness of 25 mm for 60 mm thick blocks and 30 mm for 80 mm thick blocks. Bedding sand shall be unloaded in small piles regularly placed over the base course and shall preferably have a moisture content of about 6 percent which will facilitate its spreading and compaction. Bedding sand shall be screeded in a uniform layer over the base course. The screed can be guided to level by tensioned string lines set above the base course. At the time of screeding, the thickness of sand must allow for the amount by which it will be subsequently compacted which is normally about 25 percent more than the compacted thickness. Screeding shall not proceed beyond about 1 m ahead of the planned end of block paving for the day. Sand shall preferably be compacted with a manual, fabricated plate compactor and the level shall be readjusted using the screed. The surface profile of the screeded bedding sand shall match that required for the completed pavement.

### 1504.11 Paving Pattern

The pattern in which blocks are to be paved shall be stretcher as shown below in **Fig. 1500.4**.



STRETCHER OR RUNNING

Fig. 1500.4 Stretcher Pattern

**1504.11.1** By and large, this pattern is the same as adopted for brick paving. Paving shall commence and progress from one starting line only. Wherever possible, paving shall commence adjacent to or against edge restraint.

### 1504.12 Paving and Compaction of Blocks

Blocks shall be placed at the correct angle to the start line to achieve the final orientation of the laying pattern. For curved or unfavourably oriented edge restraints, a string line shall be established to permit fast, easy laying such that it is not required to force a block between the blocks already paved. Control over alignment, laying pattern and joint width can be assisted by the use of chalked string lines set at about 5 m intervals. Nominal joint width of 2 to 4 mm shall be maintained by holding the paving unit lightly against the face of the adjacent block and allowing it to slide into position. Cutting paving units for filling the paving gaps occurring against edge restraints etc. shall be deferred until sufficient work has progressed to allow reasonably continuous operation. When space does not permit the use of cut pieces of blocks, premixed or dry packed concrete shall be used. After a section has been paved, compaction shall be effected by using vibrating plate compactors in the following sequence of operations:

- i) Vibrate the blocks with three passes of the plate vibrator of adequate capacity.
- ii) Spread a thin layer of fine joint filing sand on top of the paved blocks and sweep it into the joints, using suitable brooms.
- iii) Vibrate the sand into the joints by making three passes of the compactor.
- iv) Sweep off the excess sand from top of blocks.

As a guide to the characteristics of typical vibrating plate compactors, standard compactors have a weight of 90 kg, a plate area of 0.3 $m^2$ and apply a centrifugal force of 1500 kg. Heavy duty compactors weigh between 300 to 600 kg, have a plate area of about 0.5 to 0.6 $m^2$ and apply a centrifugal force in the range of 2000-3000 kg. Use of heavy duty compactors is desirable for trafficked pavements

#### 1504.12.1 *Trial length*

The contractor shall lay a trial length of 30 m and get it inspected and approved from the Engineer before proceeding with the regular paving work. The trial length shall be rectified/ relaid if found deficient in any respect. The procedure demonstrated in the laying of trial length shall be followed while executing the main construction work.

### 1504.13 Opening to Traffic

The pavement can be opened to traffic as soon as the construction work is completed.

### 1504.14 Surface Tolerances

#### 1504.14.1 *Transverse profile*

When measured by a camber template, the transverse profile shall not deviate by more than 10 mm from the design profile.

#### 1504.14.2 *Longitudinal profile*

When measured by a 3 m straight edge, the longitudinal profile shall not deviate by more than 12 mm from the design profile.

### 1504.15 Acceptance Criteria

From each lot of 500 blocks, five blocks shall be selected at random for water absorption and compressive strength tests. In case the number of blocks in the lot is less than 500, a minimum 1 percent of the blocks delivered to site shall be tested for water absorption and strength. The blocks shall be first tested for water absorption and these shall meet the requirement of Clause 1504.6.2.6 of these Specifications. The same five blocks (or minimum 1 percent) shall be tested for strength and shall conform to the strength as per Clause 1504.6.1 of these Specifications.

The paved surface shall meet the tolerances for lines, levels, and grades etc. as given in Section 1800 of these Specifications.

### 1504.16 Measurements for Payment

The measurement of the paved area shall be in square metres measured from the inner edge of edge restraints on one side of the pavement to the inner edge of the edge restraints on the transverse side of the pavement. The measurement of the edge restraints shall be in number of units or in cubic metres.

### 1504.17 Rate

The contract unit rate shall include the cost of blocks, cost of stacking, transportation to site and paving including supply and application of bedding sand and joint filling sand. The rate shall include full compensation for labour, tools, plant, equipment, testing and all incidentals to the work, including construction and testing of trial length, all royalties, taxes, storage rents wherever necessary, and all leads and lifts.

# 1600

# HILL ROAD CONSTRUCTION

## 1601 SITE CLEARANCE

The work of site clearance shall conform to the requirements of Section 200 of these Specifications

## 1602 SETTING OUT

### 1602.1 Reference Pillars (Alignment) and Back-Cutting Line

The reference pillars for alignment of the road shall be constructed by the Engineer at the project preparation stage. The reference pillars shall be located as shown in **Fig. 1600.1(a)**. The valley side top edge of reference pillar shall be at ground level. The size of reference pillars shall be 200 mm x 200 mm in plan and 300 mm in height [**Fig. 1600.1(b)**]. These shall be in mud masonry, plastered with 1:6 cement-sand mortar. The top levels of reference pillars shall be tied down to the level of nearest available GTS Bench Mark.

The reference pillars shall be at 20 m intervals. On sharp curves, the interval shall be 10 m. On hair pin bends, the location of reference pillars and spacings of 5 m shall be as shown in **Fig. 1600.2**.

Back-cutting line shall be demarcated on the hill face by digging, taking into account the designed slope of hill-cutting. The accuracy of hill-cutting as per drawings shall be the responsibility of the Contractor irrespective of correctness of demarcation of back-cutting line at site and hill-cutting shall match with the drawings.

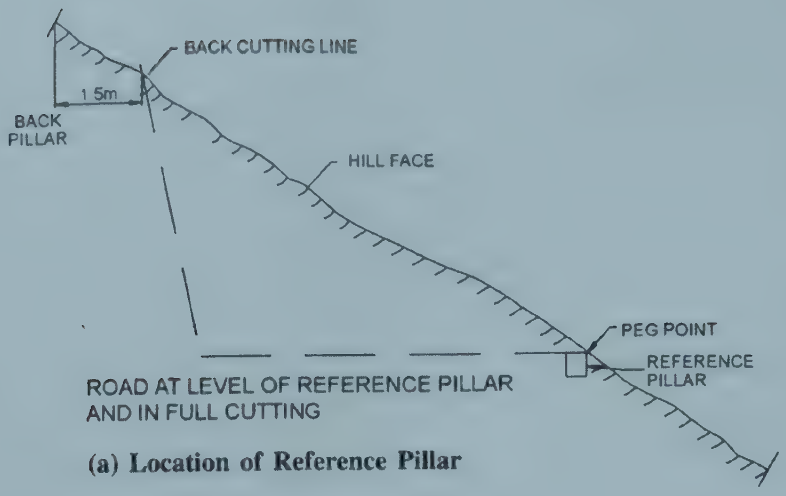
Recommended side slopes in hill-cutting shall preferably be following or as mentioned in the design:

| | |
|---|---|
| Cutting in silty/gravel/sandy soil | 1 : 1 to ½ : 1 |
| Cutting in disintegrated rocks or conglomerate | ½ : 1 to ¼ : 1 |
| Cutting in soft rock/shale | ¼ : 1 to 1/8 : 1 |
| Cutting in medium rock/sandstone/phyllite | 1/12 : 1 to 1/16 : 1 |
| Cutting in hard rocks/quartzite/granite | Nearly vertical |

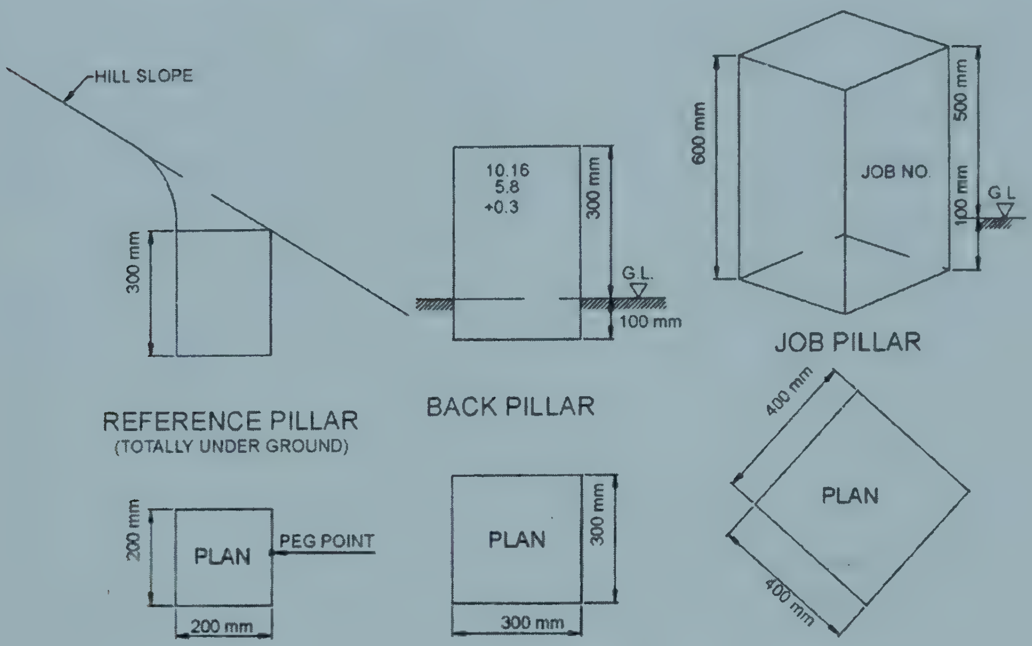
### 1602.2 Demarcating Formation Edge

The reference pillars, constructed by the Engineer, shall be taken over by the Contractor. The valley side edge of reference pillar shall represent the peg point. The Contractor shall be responsible for safeguarding and maintaining the reference pillars till completion of the work.

The Contractor shall verify the correctness of the traverse shown on the drawings with reference to reference pillars at site as shown in **Fig. 1600.3**. For setting out hair pin bend, the traverse will be continued for 30 m (at a uniform level) beyond the turning point as shown in **Fig. 1600.2**. In case any discrepancy in length (measured parallel to road grade), direction and grade is found between two reference pillars beyond the tolerances noted below, the Contractor shall immediately inform the Engineer to do the needful.


BACK CUTTING LINE
1.5m
BACK PILLAR
HILL FACE
PEG POINT
REFERENCE PILLAR
ROAD AT LEVEL OF REFERENCE PILLAR AND IN FULL CUTTING

(a) Location of Reference Pillar

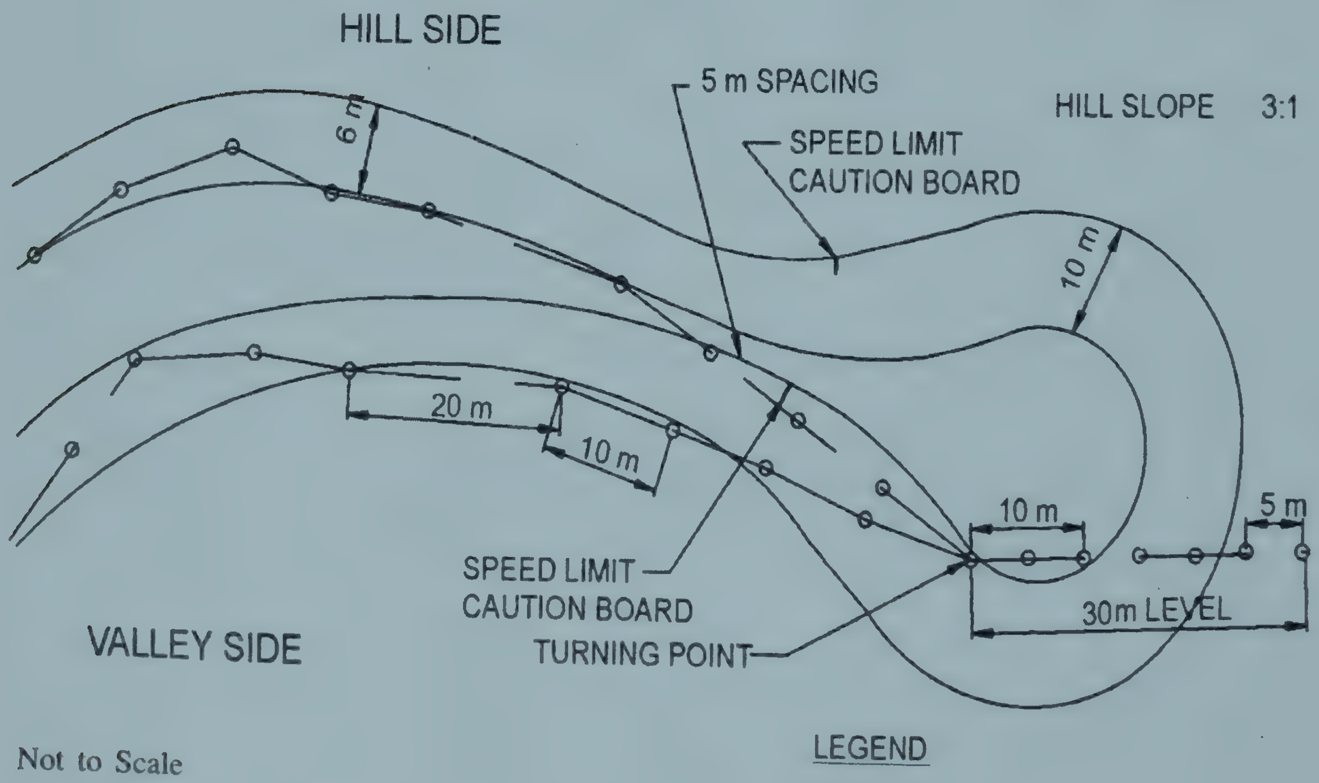

HILL SLOPE
300 mm
REFERENCE PILLAR
(TOTALLY UNDER GROUND)
200 mm
PLAN
PEG POINT
200 mm
10.16
5.8
+0.3
300 mm
G.L.
100 mm
BACK PILLAR
PLAN
300 mm
300 mm
600 mm
500 mm
100 mm
JOB NO.
G.L.
JOB PILLAR
400 mm
PLAN
400 mm

(b) Reference Pillar (c) Back Pillar (d) Job Pillar

(NOT TO SCALE)

Fig. 1600.1

HAIRPIN BEND FOR RURAL ROADS


HILL SIDE
5 m SPACING
HILL SLOPE 3:1
6 m
SPEED LIMIT CAUTION BOARD
10 m
20 m
10 m
10 m
5 m
SPEED LIMIT CAUTION BOARD
TURNING POINT
30m LEVEL
VALLEY SIDE
Not to Scale
LEGEND

Signages should be on valley side

Fig. 1600.2 Interval of Reference Pillars

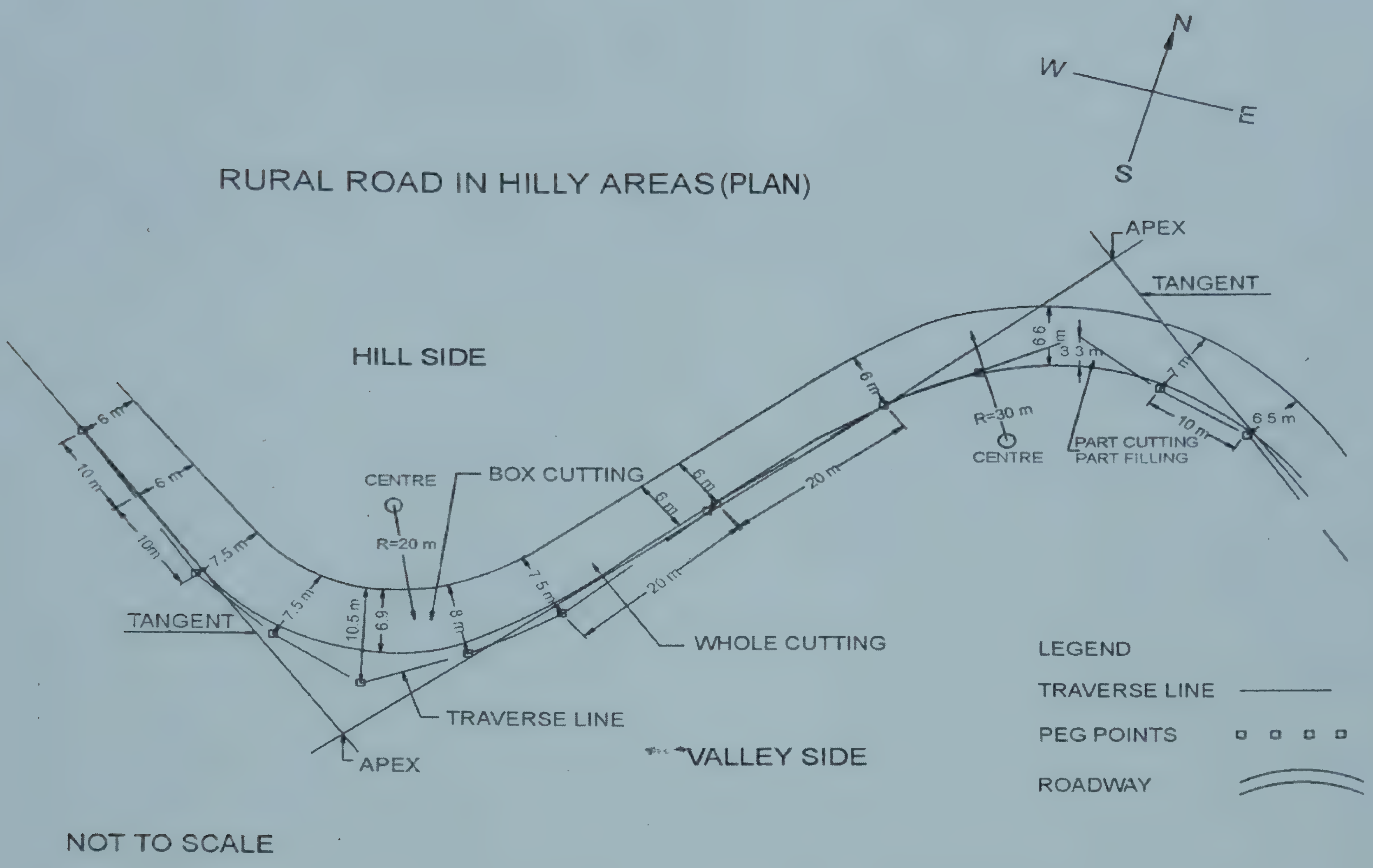

N
W
E
S
RURAL ROAD IN HILLY AREAS (PLAN)
APEX
TANGENT
HILL SIDE
6 m
10 m
6 m
10m
7.5 m
TANGENT
7.5 m
CENTRE
R=20 m
BOX CUTTING
10.5 m
6.9
8 m
7.5 m
6 m
6 m
20 m
20 m
6 m
WHOLE CUTTING
TRAVERSE LINE
APEX
VALLEY SIDE
6.6 m
3.3 m
R=30 m
CENTRE
PART CUTTING
PART FILLING
7 m
10 m
6.5 m
LEGEND
TRAVERSE LINE
PEG POINTS
ROADWAY
NOT TO SCALE

Fig. 1600.3 Verification of Correctness of the Traverse

Layout of hairpin bends shall be done at desired curves radii with due consideration to transition curves.

**Tolerances**

| | | |
|---|---|---|
| 1) | Length | ± 0.5 percent |
| 2) | Direction | ± 20 minutes |
| 3) | Grade | ± 0.2 percent |

The hill side edge of roadway (back cutting line) shall be accurately marked on the hill face, based on distances shown on the drawings, measured horizontally and accurately from reference pillars and accounting for the specified slope of hill cutting, to the satisfaction of the Engineer.

Where the road is in filling, the retaining wall shall be so constructed that its outside edge at top is accurately at a distance as shown on the drawing, measured from the reference pillar.

The roadway demarcation lines between consecutive reference pillars shall follow the curvature shown on the drawings, to the satisfaction of the Engineer.

**1602.2.1** Transferring the peg points from traverse line to centre line of the road :It shall be ensured that the longitudinal section of the road shall be drawn along the centre line of the road. The distances between peg points on the centre line shall be transferred from corresponding peg points on the traverse, radially towards the centre line curve.

### 1602.3 Back Pillars

Back pillars shall be constructed by the Contractor in front of each reference pillar, as shown in **Fig. 1600.1(c)**. The size of the back pillar shall be 300 mm x 300 mm in plan and 400 mm in height, of which 100 mm shall be below ground level. These pillars shall be located at about 1.5 m away towards hill side from the back-cutting line, and shall have the following information written on them in the order given below for proper execution of the work:

1) Location of reference pillar in km.
2) Distance of hill side edge at road level from reference pillar in m.
3) Level of the road top at centre with reference to the level from level of the top of the reference pillar (above = (+), below (-), level (0) in m.

Back-cutting pillars shall be constructed about 1.5 m away (towards hill side) from back-cutting line, so that information written over there is easily visible during hill-cutting.

### 1602.4 Job Pillars

Job pillars shall be constructed by the Contractor at site at the two ends of the job indicating location and job number as shown in **Fig. 1600.1(d)**. The size of job pillars shall be 400 mm x 400 mm in plan and 600 mm in height, of which 100 mm shall be below ground level. Job Numbers shall be written on these job pillars.

### 1602.5 Measurements for Payment

The work of setting out shall be measured in linear metres or length units specified in the bill of quantities.

### 1602.6 Rate

The Contract unit rate for the item of setting out shall be payment in full for carrying out the required operations including full compensation for all labour, material, tools, equipment, construction and establishing benchmarks, making back cutting lines, back pillars, job pillars and their safeguarding and incidentals necessary to complete the work.

## 1603 EARTHWORK

### 1603.1 Earthwork in Excavation

All earthwork in excavation, including rock excavation, shall be carried out true to lines, grades, side slopes, width, camber, super-elevation and levels as shown on the drawings or as directed by the Engineer, in conformity with the requirements of Section 300 of these Specifications.

Identification of areas for proper disposal of debris and waste materials shall be done before commencement of work. Safe disposal of materials shall be done as per direction and satisfaction of the Engineer. The Contractor shall arrange necessary construction equipment and adequate labour camps and camp equipage at his own cost. Prompt removal of debris shall also be ensured by the Contractor at his own cost.

Hill cutting shall be done in a manner so that deforestation comes to minimum so as to reduce the environmental imbalance. It shall be done in conformity with Environment Management Plan after assessment of impact on environment. Necessary mitigation measures shall be ensured before start of hill-cutting work.

### **1603.1.1** *Transferring designed widths, curves and grades to the ground*

At desired road level, the hill side hill-cutting edge shall be at a distance specified in the drawing as measured from outside edge of reference pillar. For sections in filling, the outside edge of retaining wall shall be located at a distance specified in the drawings and measured from the outside edge of the reference pillar, measured along road level. Construction shall proceed in such a manner that the curvature of hill side and valley side edges shall be same as per drawings. Formation level at centre line of the carriageway shall be as per levels indicated on corresponding back-pillars, so that desired gradient is achieved.

Width of prescribed roadway for hilly terrain is inclusive of parapet and hillside drains. Extra widening at curves shall be provided as per drawings. On roads subjected to snowfall, width of roadway shall be increased by 1.5 m or as indicated in drawings at the design stage.

### **1603.1.2** *Extra widening at curves*

Extra widening at curves shall be done in accordance with Rural Roads Manual. Sight distance shall be improved by batter benching which shall be done by benching the hill side above 1.20 m height from road level. This shall be executed if provided in design and drawings.

### **1603.1.3** *Passing places*

These shall be provided at the rate of 2 to 3 per km in accordance with Rural Roads Manual.

### **1603.1.4** *Hairpin bends*

These shall be provided, if unavoidable, as per design of circular curve with transition at each end in accordance with Rural Roads Manual. These shall be located at stable and easy hill-slopes and shall be avoided at inner curves to keep away from drainage problems. Full width of roadway shall be surfaced to avoid erosion. One cross drain shall be provided on upper arm of hairpin bend just before the bend, in order to minimize flow of water along the surfaced road and to reduce erosion.

## 1603.2 Rock Cutting

All work of rock cutting by blasting shall be carried out true to lines, grades, side slopes, width, camber, super-elevation and levels as shown on the drawings or as directed by the Engineer, in conformity with the requirements of Section 300 of these specifications. The Contractor shall take all necessary precautions against soil erosion, damage to hill side, water pollution, etc. and to protect stability of hill side.

### 1603.3 Safeguarding Reference Pillars

Earthwork in excavation and rock cutting shall be carried out in such a way that the reference pillars are safeguarded to the maximum possible extent. The construction section for hill cutting shall be restricted to two chain length (40 m). The next chain length shall be taken up only when the work in first chain length is completed, in order to avoid the possibility of damage or dislocation of more than two reference pillars in one continuous length of two chains.

When due to excavation or rock blasting or any other reason, a reference pillar is damaged or dislodged, the Contractor shall immediately inform the Engineer. The Engineer shall relocate the reference pillar with the help of alignment from adjoining intact pillars and at the cost of the Contractor.

The excavation or rock cutting work to be in operation in more than one stretch, sufficiently separated from each other, can be done with the approval of the Engineer.

Heavy rock-blasting shall be avoided and controlled blasting shall be resorted to by using shallow holes and low explosives charge. Blasting must be adequately supervised by technical personnel of the Contractor at site at his own cost. Selection of blasting holes shall be done so as to avoid large scale disturbance to the rock-face developing cleavage planes/cracks/ opening of fissures, etc. Rock-cutting shall be done at appropriate angle so as to achieve the desired hill slope as specified in the drawings.

### 1603.4 Excavation for Structures

All excavation for structures, such as culverts, hillside drains, catch water drains, retaining walls, breast walls shall be true to lines, grades, cross sections, shown on the drawings or as directed by the Engineer, in accordance with the requirements of Section 300 of these Specifications.

#### 1603.4.1 *Safe-disposal of debris*

Debris from excavation/blasting shall be disposed of systematically with due consideration to avoiding adverse effect on environment. It shall not be thrown haphazardly down the hill slopes as this is likely to trigger off land slides, heavy siltation, choking of water channels/ streams and damage to agricultural land and private/govt. property. It shall be stacked at identified locations along road-side or away from it to the satisfaction of the Engineer, as specified in the contract. It shall be placed at such locations so that it does not get easily washed away during rains. It shall either be turfed or shall be provided with vegetative cover as per provisions of the contract.

### 1603.5 Embankment Construction

Embankment construction including filling behind retaining walls, shall be carried out true to lines, grades, side slopes, widths, cambers, super-elevations and levels as shown on the drawings or as directed by the Engineer and in conformity with the requirements of Section 300 of these Specifications.

### 1603.6 Useful Finds

Any finds, such as, relics of antiquity, coins, fossils or other articles of value, shall be promptly delivered to the Engineer, free of cost and shall remain the property of the Government.

### 1603.7 Preparation of Cut Formation

The cut formation which serves as a sub-grade, shall be prepared to receive the sub-base, base and pavement courses, in accordance with the requirements of Section 300 of these Specifications.

### 1603.8 Cross Section and Road Profile

The Contractor shall be responsible for providing, formation width, curves, grades, grade compensation, camber, super-elevation as specified in the Contract or shown on the drawings or as directed by the Engineer and upto the tolerances noted below:

| | | |
|---|---|---|
| 1) | Width of formation | (+) 5%, (-) 1% |
| 2) | Longitudinal grade | ± 5% of the specified grade |
| 3) | Grade compensation | ± 5% of the specified gradient |
| 4) | Super elevation | ± 5% of the specified superelvation |

**1603.8.1** Preparation of completion plan and verification of curve radius and gradient and rectification of defects : Completion plan of the completed lengths shall be prepared and compared with the drawings of the contract in regard to widths, curve radius, camber, super-elevation and the longitudinal gradient.

The defects so marked shall be rectified by the Contractor at his own cost and in case still some defects are left within permissible limits, the cost of the same shall be deducted from the Contractor as per conditions of the contract. Suitable cost deduction clause shall be provided in the contract in such a way that remaining work can be completed upto finished stage within the cost so deducted from the Contractor.

### 1603.9 Finishing Operations

The finishing operations shall be in accordance with the requirements of Section 300 of these Specifications.

No permanent construction shall be started over the cut or fill surface until and unless approved by the Engineer.

### 1603.10 Measurements for Payment

Measurements for payment of the works of Earthwork in Excavation, Rock Cutting, Excavation for structures and embankment construction shall be carried out in accordance with the requirements of Section 300 of these Specifications.

### 1603.11 Rate

The contract unit rates for earthwork in excavation, rock cutting, excavation for structures and embankment construction shall be in accordance with the requirements of Section 300 of these Specifications.

## 1604 RETAINING WALLS/BREAST WALLS/GABIONS

Retaining/Breast walls/Gabions for stability of valley side and hill side slopes shall be provided as per provision in the contract and after the approval of the Engineer.

### 1604.1 Earthwork

The earthwork for foundation shall conform to the requirements of Section 300 of these Specifications. The depth of foundation shall be as shown on the drawing or as directed by the Engineer. The foundation bed shall have 3:1 (H:V) slope towards hill side.

For demarcation of foundation bed of retaining walls, the top width of wall section shall be laid out with the help of bamboos and strings. The strings shall be hung from bamboos according to the designed front and backslopes. In case of breast-walls, the outer edge of the wall, at road level, shall be the same as the hill side edge of roadway. In case of stable rocks, the foundation bed of retaining walls shall be stepped up with 150 mm depth in hard rock and 600 mm in soft rock.

### 1604.2 Materials

All materials used in stone masonry shall conform to the requirements of Sections 700 and 2000 of these Specifications.

In case of retaining/breast wall in plum concrete, the stone plums shall conform to the requirements of Sections 800 and 2000 of these Specifications.

The material to be used in gabion for stone and for wire crates shall conform to the requirements of Section 1300 of these Specifications.

### 1604.3 Masonry Work

The masonry of retaining/breast walls shall be of random rubble dry masonry conforming to Section 700 of these Specifications or random rubble dry masonry with 1:6 cement masonry bands or with a course of cement concrete 1:4:8 throughout the section both in length-wise and breadth–wise direction of the wall or as shown on the drawings or as directed by the Engineer. The bands shall be 0.6 m wide with clear space of 3 m between them, both horizontally and vertically.

The depth of foundation shall be as shown on the drawing or as directed by the Engineer and shall be safe from scour, frost and surface water. The foundation pit in front of wall shall be filled upto original ground level and well compacted. In case of retaining wall, the top course shall be horizontal and in case of breast wall, it shall be sloping down 2:1(H:V) towards valley side.

The masonry work shall start only after prepared foundation has been approved by the Engineer.

The top level of retaining wall shall match the adjoining shoulder edge with camber/super elevation and shall not be an obstruction to water flowing towards it.

### 1604.4 Bond Stones

The bond stones shall conform to the requirements of Section 700 of these Specifications. The bond stones shall be provided in dry stone masonry. The spacing of the bond stones shall be 1 m horizontally and 0.5 m vertically.

### 1604.5 Plum Concrete Work

The work shall be carried out as per requirements of Section 800. Nominal mix 1:4:8 (1 cement: 4 Sand: 8 Graded Stone Aggregare 40 mm nominal size) shall be used with 15 percent plums.

### 1604.6 Gabion

The mesh of the gabion shall be hexagonal in shape with opening size 100 mm x 100 mm. The box shall not be larger than 3 m x 1.5 m x 1.25 m. Wherever the length of the box is more than 1.5 m diaphragms of the same material as the parent gabion shall be provided to prevent bulging.

The gabion shall be installed only after the foundation has been prepared as per Section 1600 and approved by the Engineer. The fabrication and installation of gabion unit shall be carried out as per Section 1300 of these Specifications. When a structure requires more than one layer of units, the upper layer shall be connected to the top of the lower layer along the front and back edges as directed by the Engineer.

### 1604.7 Back Fill

The back fill behind retaining wall /breast wall/gabion work shall be done only after the masonry/plum concrete work of wall/gabion work has been approved by the Engineer.

The backfill shall conform to the requirements of Section 300 of these Specifications.

The surface shall be filled with impervious material to prevent seepage of water behind the retaining wall. Back filling shall not be started until retaining wall has attained a suitable height to the satisfaction of the Engineer.

### 1604. 8 Measurements for Payment

Stone masonry random rubble dry and random rubble in cement mortar, plum concrete and gabion including boulders shall be measured separately. Back fill shall be measured in cubic metres, on the basis of mean length, mean thickness and mean height. Any unauthorized work done by the Contractor shall not be measured. Bond stones shall not be measured separately.

### 1604. 9 Rate

The contract unit rate for earthwork in excavation, stone masonry/ plum concrete/gabion and back filling shall include the cost of all labour, material, tools and plants, scaffolding, sampling, testing, supervision and other expenses incidental to the completion of the work as described here in above.

## 1605 PAVEMENT CONSTRUCTION

### 1605.1 Sub-grade Construction

The sub-grade construction shall conform to the requirements of Section 300 of these Specifications.

### 1605.2 Granular Sub-Base and Bases

The granular sub-base and base course construction shall be in accordance with the requirements of Section 400 of these Specifications.

### 1605.3 Bituminous Construction

The bituminous construction shall be in accordance with the requirements of Section 500 of these Specifications.

### 1605.4 Tolerances

The tolerances in the various courses of pavement shall conform to the relevant provisions of Section 1800 of these Specifications.

### 1605.5 Measurements for Payment

The measurement shall conform to the requirements of Section 500 of these Specifications.

### 1605.6 Rate

The rate shall conform to the requirements of Section 500 of these Specifications.

## 1606 DRAINAGE

Appropriate system of drainage shall be provided depending upon site requirement. Initial studies shall be done regarding identification of any sediment traps and its effect on drainage. Adverse effect of nearby streams, lakes and ponds shall also be studied at design stage keeping in view that existing drainage facilities are not disturbed. Need for provision of catch water drain shall also be studied. Adequate drainage shall then be designed based on available hydrological data.

### 1606.1 Hill side Drain

Hill side Drain shall be of the shape as specified in the drawings and preferably of V-shape with normal flow and of trapezoidal shape in case of heavy flow of water.

**1606.1.1** This work shall consist of constructing hill side drain in accordance with the requirements of these Specifications and true to lines, grades, dimensions and other particulars shown on the drawings or as directed by the Engineer. Schedule of work shall be so arranged that the drain is completed in proper sequence with road works, to ensure that no excavation of completed works is necessary subsequently or any damage is caused to these works due to lack of drainage.

The trapezoidal drain shall be designed as per anticipated volume of the discharge and shall also have guide posts of RCC or stone masonry along the edge for safety of the traffic. Proper outfall design shall be ensured for efficient drainage.

### 1606.1.2 *Materials*

All materials for construction of hillside drain shall conform to relevant provisions and Section 2000 of these Specifications.

### 1606.1.3 *Construction work*

The excavation in rock for hillside drain shall preferably be done along with hill side cutting for ease of construction. Earthwork in excavation for hill side drains shall be true to the specified lines, grades, levels and dimensions and in accordance with the requirements of Section 300 of these Specifications. The excavated materials shall be removed from the area adjoining the drain and if found suitable, utilized in sub-grade construction. All unsuitable material shall be disposed of as directed by the Engineer.

The excavated bed and sides of the drain shall be dressed to bring these in close conformity with the specified dimensions, levels and slopes.

Where the sub-grade is erodible or when directed by the Engineer, the drain shall be lined with random masonry coursed with 1:5 cement sand mortar conforming to the requirements of Section 700 of these Specifications or any other suitable material shown on the drawings of the size as shown in **Fig. 1600.4** or as directed by the Engineer. Where lining of concrete is not specified, the concrete shall be of M10 grade and of thickness 150 mm or as directed by the Engineer.

Where the drain is constructed in unerodible rocky strata, the excavated surfaces shall be dressed as specified with M15 grade concrete.

The cement concrete/cement mortar lining shall be cured for at least 7 days before opening the drain.

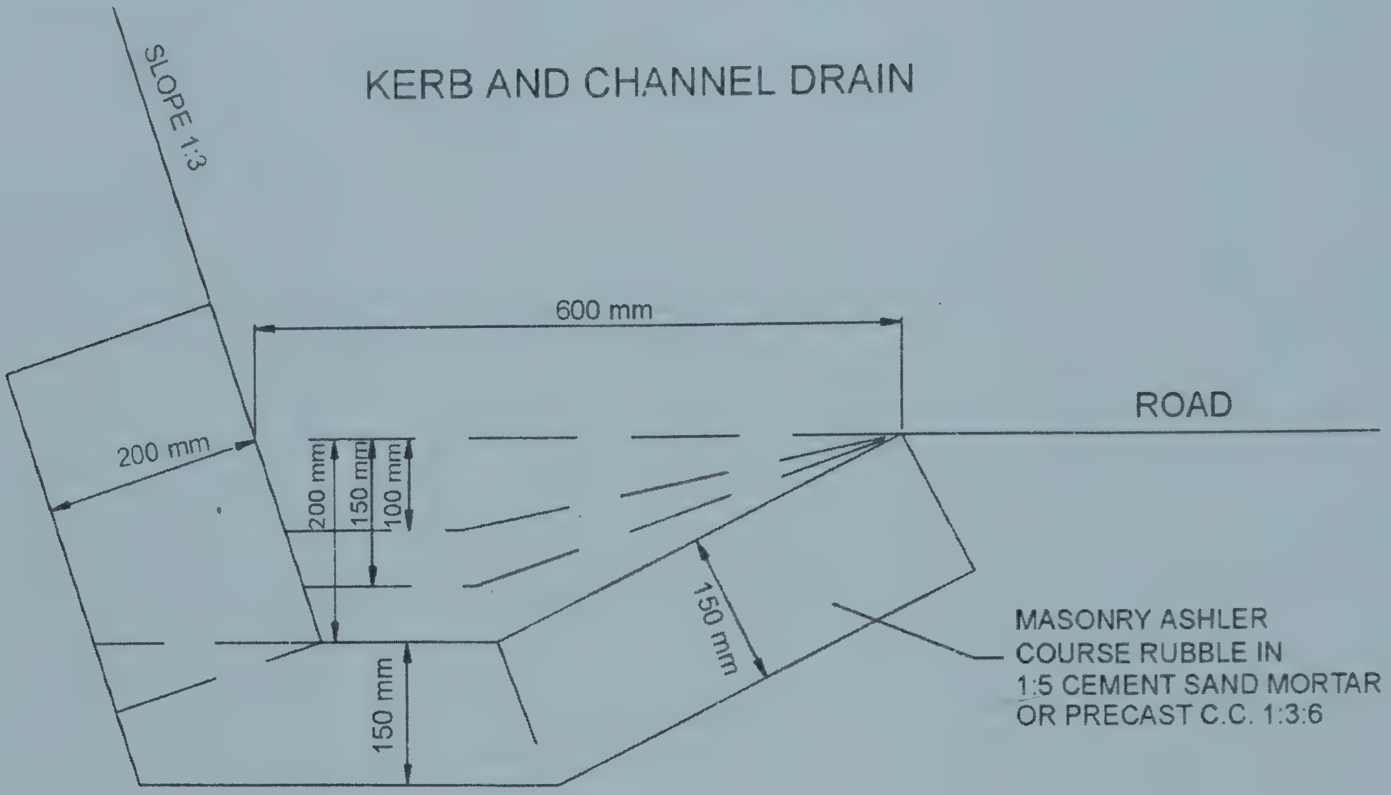
### 1606.1.4 *Measurements for payment*

Measurement for hill side drains shall be as per running metre length of the drain. Disposal of surplus material beyond 1000 m shall be measured in cubic metres.

### 1606.1.5 *Rate*

The Contract unit rate for hill side drains shall be payment in full for all items, such as excavation, dressing the sides and bottom, providing lining, masonry, concrete, plastering, levelling course, including full compensation for all material, labour, tools and other incidentals to complete the work as shown on the drawings and with all leads upto 1000 m and all lifts, for removal of unsuitable material.

The Contract unit rate for disposal of unsuitable material beyond the initial lead of 1000 m shall be in accordance with Section 300 of these specifications.


KERB AND CHANNEL DRAIN

TOP WIDTH = 600 mm
BOTTOM WIDTH = 150 mm
DEPTH = 100, 150, 200 mm AS REQUIRED

NOT TO SCALE

Fig.1600.4

### 1606.2 Catch Water/Intercepting Drain

**1606.2.1** Catch water/Intercepting Drain shall be provided on hill slopes to intercept water flowing from upper reaches to prevent it from entering slide/unstable areas. These drains shall be provided over stable slopes, outside periphery of slide, and unstable areas, as per drawings of the Contract. Surface-cum-trench drains may also be provided at critical locations where subsurface water needs to be intercepted.

Map for identification of unstable areas need to be prepared before taking up work.

These drains shall generally be of trapezoidal shape. The lining shall be of RR dry stone masonry as per design/drawing to the satisfaction of the Engineer. Where the strata is pervious, the masonry shall be in cement sand mortar, preferably 1:6 or at least pointed with 1:6 cement sand mortar. The catch-water drains shall be located close to the periphery of the area to be protected and shall be located in stable areas.

**1606.2.2** *Materials*

All materials for construction of catch water/intercepting drain shall conform to relevant provisions and Section 2000 of these Specifications.

### 1606.2.3 *Construction*

The earthwork in excavation for catch water/intercepting drain shall be true to the specified lines, grades, levels and dimensions and in conformity to the requirements of Section 300 of these Specifications. The excavated material shall be removed from the area adjoining the drain and if found suitable, utilized in sub-grade construction or filling work. All unsuitable material shall be disposed of as directed by the Engineer.

The excavated bed and sides of the drain shall be dressed to bring these in close conformity with the specified dimension, levels, and slopes.

The lining of the drain shall be cured for 7 days.

### 1606.2.4 *Measurements for payment*

Measurement for catch water/intercepting drain shall be per running metre length of the drain. Disposal of surplus material shall be measured in cubic metres.

### 1606.2.5 *Rate*

The Contract unit rate for catch water/intercepting drains shall be payment in full for all items such as excavation, dressing the sides and bottom, providing masonry, concrete, pointing, plastering as specified, including full compensation for all material, labour, tools and other incidentals to complete the work as shown on the drawings and with all leads upto 1000 m and all lifts, for removal of unsuitable material. The contract unit rate for disposal of unsuitable material beyond the initial lead of 1000 m shall be in accordance with Section 300 of these Specifications.

## 1606.3 Causeways

Causeways shall be constructed conforming to the requirements of Section 1100 of these Specifications.

## 1606.4 Pipe Culverts

Pipe culverts shall be constructed conforming to the requirement of Section 1100 of these Specifications.

## 1606.5 Scupper

**1606.5.1** Scupper is a cross drainage structure, provided on hill roads, made with locally available stones. This is constructed generally with dry stone masonry.

Design of dry stone scupper shall be as per Rural Roads Manual. Number of scuppers per km shall also be specified as per Rural Roads Manual depending upon rainfall. When scuppers are constructed at inner curves, top surface shall be in accordance with super-elevation.

In case, location of a scupper is likely to cause damage to a property or agricultural field, its relocation shall be decided by the Engineer.

### 1606.5.2 *Material*

Stone for scupper shall be hard, sound, free from decay, weathering, cavities, patches of loose or soft materials or other such defects that may adversely affect the strength of scupper. Stone with round surface shall not be used. The size of stone shall conform to the requirements of Section 700 of these Specifications.

### 1606.5.3 *Earthwork*

*1606.5.3.1* The earthwork in excavation for foundation of abutments, catch pit and flooring shall conform to the requirements of Section 300 of these Specifications.

*1606.5.3.2* Where stable rock is encountered, the rock shall be used as abutments, and breast walls in catch pits.

### 1606.5.4 *Construction*

The scupper shall be constructed as per details shown on the drawings.

The abutments, breast wall and Kharanja (stone on edge) shall be of random rubble dry stone masonry. The corbelling shall be of random rubble coursed dry stone masonry.

The cushion over corbelling shall be of thickness not less than 600 mm. The cushion shall be of hand packed stone, locally available or any other approved granular material compacted, conforming to the requirements of Section 300 of these Specifications.

Where filled up soil or any other unsuitable strata is encountered, the whole structure shall be taken down to rest on suitable strata, as directed by the Engineer.

Generally, the scuppers shall have 1 m wide abutments unless specified otherwise in the drawings. The corbelling stone shall be provided preferably not less than 450 mm in length and not less than 150 mm wide and with a minimum thickness of 150 mm. There shall be 3 corbelling projections on each side with each projection being 150 mm preferably or as per design and drawings. Corbelling stones shall be collected in advance before the foundation excavation is permitted by the Engineer. These shall be hammer dressed.

#### *1606.5.4.1 Side retaining walls on both ends of scuppers*

Hill side and valley side retaining walls, i.e., on both ends of scuppers shall be with a batter of 1:3 (Horizontal : Vertical) towards outer-side. When the bed of water course is lower than the bed of scupper, the whole structure shall be taken down to firm base and thickness of cushion shall be increased accordingly.

#### *1606.5.4.2 Safe disposal of drainage water from scuppers*

It shall be ensured that water is disposed of safely from scuppers. It shall be led away from dwellings, fields, etc. to avoid damage. Drains leading to safe disposal points shall be lined if so required.

### 1606.5.5 *Measurements for payment*

The scupper shall be measured as complete work along its length (formation width of road) in metres. The catch pit shall not be measured separately.

### 1606.5.6 *Rate*

The Contract unit rate for scupper shall include the cost of complete work including catch pit and shall include full compensation for all labour, material, tools, equipment and other expenses incidental to the completion of the work in accordance with the requirements of these Specifications.

## 1607 PROTECTIVE WORKS

Protective works include retaining walls, breast walls, parapet walls, railings, edge stones, toe walls, check walls, river training structures, etc. which are required either for slope stabilization or safety against erosion in normal alignments or slope failure and erosion of toe for alignment along river banks. By hill-cutting, natural stability of hill slope gets disturbed. Soil movement may also cause instability of slopes. Their studies shall be done prior to road construction at design stage and appropriate structure shall be designed accordingly. Some structures are also needed to protect the public property which is disturbed due to road-construction.

### 1607.1 Apron

The work of apron shall be done in accordance with the requirements of Section 1300 of these Specifications.

### 1607.2 Pitching on Slopes

The work of pitching on slopes shall be done in accordance with the requirements of Section 1300 of these Specifications.

### 1607.3 Rubble Stone/Brick Flooring over Cement Concrete Bedding

The work of Rubble stone/Brick flooring over cement concrete flooring shall be done in accordance with the requirements of Section 1300 of these Specifications.

### 1607.4 Curtain Walls

The work of curtain walls shall be done in accordance with the requirements of Section 1300 of these Specifications.

### 1607.5 Soil Erosion and Sedimentation Control

The work of soil erosion and sedimentation control shall be done in accordance with the requirements of Section 300 of these Specifications.

### 1607.6 Bed Scouring

The outside bed of a cross drainage structure or the outfall of a drain may be through a retaining wall and as such the water falls as a free fall which sometimes causes erosion of the toe of the wall at soft reaches. To check erosion at such points, one or a series of toe walls along with apron shall be constructed in order to break the water force and check scouring at the bed.

## 1608 SAFETY DEVICES AND MEASURES

### 1608.1 Traffic signs

Traffic signs shall be provided in accordance with the requirements of Section 1700 of these Specifications.

### 1608.2 Guide Posts

The work shall consist of providing RCC guide posts of the size and shape and at locations as specified on the drawings.

### 1608.2.1 *Materials*

Materials for RCC guide posts shall conform to relevant provisions and Section 2000 of these Specifications.

**1608.2.2** Guide Posts shall be of reinforced cement concrete of M15 grade or as specified on the drawings or as directed by the Engineer.

The Guide Posts shall be 250 mm diameter and of height as specified on the drawings and embedded in concrete as indicated on the drawings

The Guide Posts shall be white washed.

### 1608.2.3 *Measurements for payment*

The Guide posts and edge stones shall be measured in numbers.

### 1608.2.4 *Rate*

The Contract unit rate for Guide Posts shall be payment in full compensation for furnishing all labour, material, tools, equipment for preparing, supplying, fixing, white washing and all other incidental costs to complete the work.

### 1608.3 Railings/Parapets

The Railings/Parapets shall be provided in accordance with the relevant provisions of these Specifications.

### 1608.4 Edge Stones

**1608.4.1** Edge stones roughly dressed about 300 mm in height over the road level shall be provided on the valley side edge of formation as shown in **Fig. 1600.5** or as shown on the drawings or as directedby the Engineer, specially in areas prone to fog.

**1608.4.2** Edge stones shall be of locally available rocks of sufficient length and white washed.

**1608.4.3** Measurements for payment: Edge stones shall be measured in number.

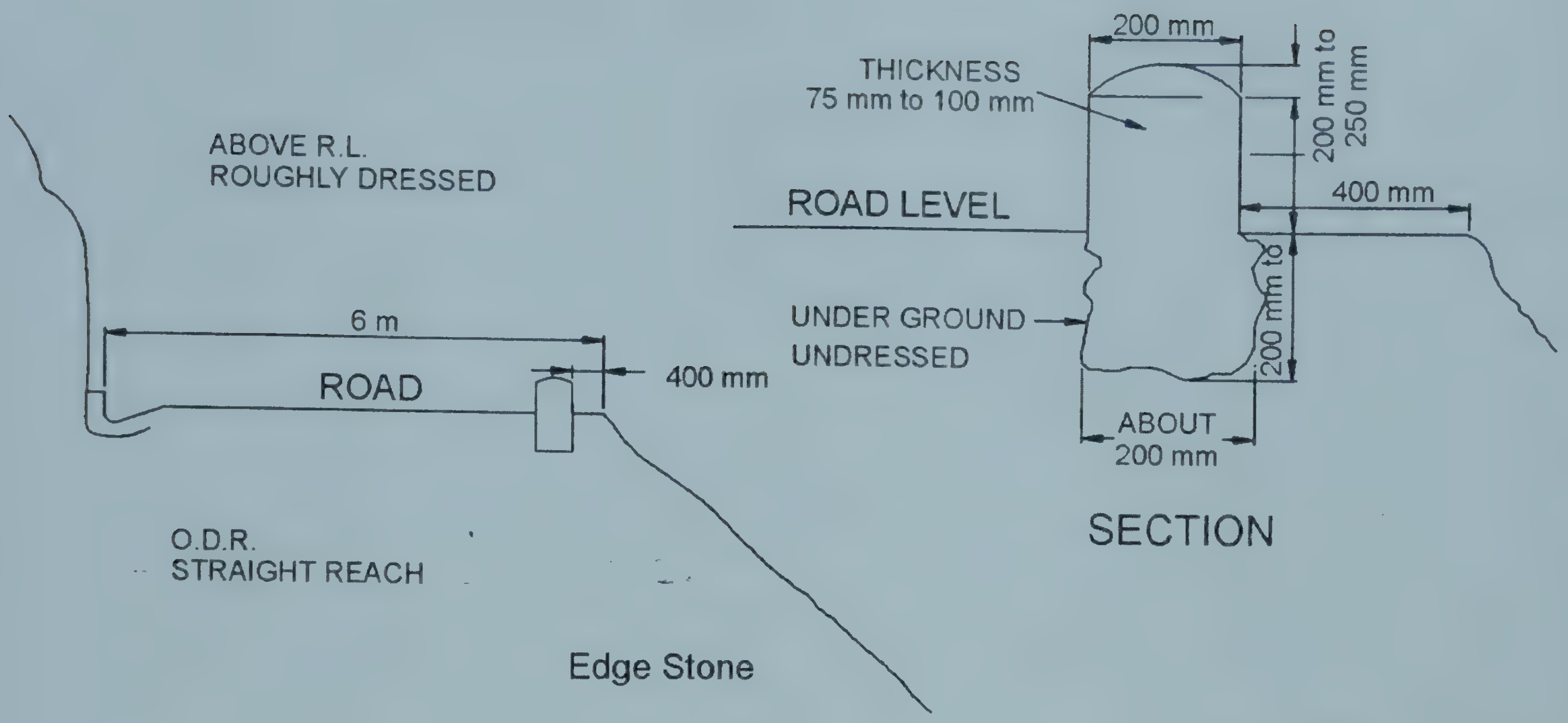

ABOVE R.L.
ROUGHLY DRESSED
6 m
ROAD
400 mm
O.D.R.
STRAIGHT REACH
Edge Stone
200 mm
THICKNESS
75 mm to 100 mm
200 mm to 250 mm
ROAD LEVEL
400 mm
UNDER GROUND
UNDRESSED
200 mm to
ABOUT
200 mm
SECTION
NOT TO SCALE

Fig. 1600.5

**1608.4.4** *Rate*

The contract unit rate for Edge Stone shall be payment in full for furnishing all labour, materials, tools, equipment, for completion of work as per requirement of these Specifications.

### 1608.5 Traffic Safety and Control

**1608.5.1** The Contractor shall take all necessary effective measures for traffic safety and control in accordance with the requirements of Section 100 of these Specifications.

**1608.5.2** *Precautions during blasting operations*

*1608.5.2.1* Blasting operations shall be carried out in accordance with the requirements of Section 300 of these Specifications.

## 1609 PRECAUTIONS FOR SAFEGUARDING THE ENVIRONMENT

Precautions and measures for safeguarding the environment shall be taken in accordance with Section 2100 of these Specifications.

## 1610 HILL SLOPE PROTECTION

### 1610.1 Soil Erosion and Sedimentation Control

The Contractor shall take all necessary measures against soil erosion and sedimentation in conformity to the requirements of Section 300 of these Specifications.

Cut-slopes shall be rendered stable in construction stage itself by cutting and ensuring appropriate hill cut slopes as specified in Clause 1602.1. Wherever necessary, cut/denuded slopes shall be treated with appropriate slope stabilization measures as provided in contract conditions.

### 1610.1.1 *Some aspects to be seen prior to hill-cutting*

Before start of hill road construction work, studies shall be done, such as, need for diversion, treatment of sensitive slopes and whether it shall be feasible to cut the disturbed hill slopes or some alternatives, like bridges and tunnels shall be more stable, etc. Study of temporary erosion control measures between successive construction measures shall also be done and necessary mitigation measures may be adopted in the design. These studies shall be carried out in consultation with geological and forest department authorities. Identification of natural water courses shall also be done before hand because at certain locations, additional out burst of water from hill side drain may cause soil erosion. Toe-erosion near rivers and heavy flow of streams shall also be studied which causes subsidence of the hill road and necessary mitigation measurers shall be provided in the design.

## 1610.2 Turfing with Sods

### 1610.2.1 *Scope*

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on benched hill side slopes, embankment slopes, verges or other locations shown on the drawings or as directed by the Engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment, provided the season is favorable for establishment of the sod. Pre-monsoon season is considered to be the best period for turfing with sods.

### 1610.2.2 *Materials*

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be used, and shall be free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm and the sod shall have been freed of debris.

**1610.2.3** Thickness of the sod shall be as uniform as possible, with some 50-80 mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm x 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

### 1610.2.4 *Construction operations*

#### *1610.2.4.1 Preparation of the earth bed*

The area to be sodded shall have been previously constructed to the required slope and cross section. Soil on the area shall be loosened, freed of all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25 mm for receiving the sod.

Where required, topsoil shall be spread over the slopes. Prior to placing the top soil, the slopes shall be scarified to a depth which, after settlement, will provide the required nominal depth shown on the plans. Spreading shall not be done when the ground is excessively wet.

Following soil preparation and adding top soil, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the plans. After spreading, the materials are incorporated in the soil by discing or other means to the depths shown on the plans.

### *1610.2.4.2 Placing the sods*

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same had been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

On side slopes steeper than 2 (horizontal) to 1 (vertical), the laying of sods shall be started from bottom upwards. At points where water may flow over the sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its thorough compaction.

### *1610.2.4.3 Staking the sods*

Where the side slope is 2 (horizontal) to 1 (vertical) or steeper and the distance along the slope is more than 2 m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000 mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

### *1610.2.4.4 Top dressing*

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign materials. Thereafter, a thin layer of topsoil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water.

### *1610.2.4.5 Watering and maintenance*

The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks.

The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance.

### **1610.2.5** *Measurements for payment*

Turfing with sods shall be measured as finished work in square metres.

### 1610.2.6 *Rate*

The Contract unit rate for turfing with sods shall be payment in full for carrying out all the required operations indicated in these Specifications including compensation for:

i) furnishing all the materials to be incorporated in works with all leads and lifts; and

ii) all labour, tools, equipments and incidentals to complete the work in accordance with these Specifications.

The Contract unit rate of the items of stupping and storing top soil and of application of top soil shall include full compensation for all the necessary operations including all lifts, but lead of 1000 m.

## 1610.3 Seeding and Mulching

### 1610.3.1 *Scope*

This shall consist of preparing slopes, placing topsoil, furnishing all seeds, commercial or organic fertilizers and mulching materials, providing jute netting and placing and incorporating the same on embankment slopes or other locations directed by the Engineer or shown in the Contract documents.

### 1610.3.2 *Materials*

A) **Seeds :** The seeds shall be of approved quality and type suitable for the soil on which these are to be applied, and shall have acceptable purity and germination to requirements set down by the Engineer. Fertilizer shall consist of standard commercial material and conform to the grade specified. Organic manure shall be fully putrefied organic matter such as cow dung.

Mulching materials shall consist of straw, hay, wood shaving or sawdust, and shall be delivered dry. They shall be reasonably free of weed seed and such foreign materials as may detract from their effectiveness as a mulch or be injurious to the plant growth.

B) **Topsoil :** Topsoil shall not be obtained from an area known to have noxious weeds growing in it. If treated with herbicides or sterilents, it shall be got tested by appropriate agricultural authority to determine the residual in the soil. Topsoil shall not contain less than 2 percent and more than 12 percent organic matter.

C) **Bituminous Emulsion :** A suitable grade of bituminous cutback or emulsion used as a tie down for mulch shall be as described in the Contract document or as directed by the Engineer. Emulsified bitumen shall not contain any solvent or diluting agent toxic to plant life.

D) **Netting :** Jute netting shall be undyed jute yarn woven into a uniform open weave with approximate 25 mm square openings. The colour may be black or green. It shall weigh not less than 3.8 kg per 1000 sqm.

Geonetting shall be made of uniformly extruded rectangular mesh having mesh opening of 20 mm x 20 mm.

### 1610.3.3 *Seeding operations*

#### *1610.3.3.1 Seed-bed preparation*

The area to be seeded shall be brought to the required slope and cross-section by filling, reshaping eroded areas and refinishing slopes, medians, etc. Topsoil shall be evenly spread over the specified areas to the depth shown on the plans, unless otherwise approved by the Engineer. The seed-bed preparation shall consist of eliminating all live plants by suitable means using agricultural implements. All stones 150 mm in smallest dimension and larger shall be removed. The soil shall be excavated on the contour to a depth of 100 mm. All clods larger than 25 mm in diameter shall be crushed and packed. Where necessary, water shall then be applied. All topsoil shall be compacted unless otherwise specified or approved by the Engineer. Compaction shall be done by slope compactor, cleated tractor or similar equipment approved by the Engineer. Equipment shall be so designed as to produce a uniform rough textured surface ready for seeding and mulching and which will bond the topsoil to the underlying material. The entire area shall be compacted by a minimum of 4 passes or 2 round trips of the roller or approved equipment.

#### *1610.3.3.2 Fertilizer application*

Required quantity of fertilizer shall be spread and thoroughly incorporated into the soil surface as part of the seed-bed preparation.

#### *1610.3.3.3 Planting of seeds*

All seeds shall be planted uniformly at the approved rate immediately after sowing, the area shall be rake dragged or otherwise so as to cover the seeds to a depth of 6 mm.

The operation of seed sowing shall not be performed when the ground is muddy or when the soil or weather conditions would otherwise prevent proper soil preparation and subsequent operations.

#### *1610.3.3.4 Soil moisture and watering requirements*

Soil-moisture shall exist throughout the zone from 25 mm to at least 125 mm below the surface at the time of planting.

Watering of the seeded areas shall be carried out as determined by the Engineer.

#### *1610.3.3.5 Applying, mulching bituminous emulsion and/or jute netting/geonetting*

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed so as to form a continuous, unbroken cover of approximate uniform thickness of 25 mm using an acceptable mechanical blower. Mulching material shall be held in place and made resistant to being blown away by suitable means approved by the Engineer. When called for in the Contract documents, mulch material shall be anchored in place with bituminous emulsion applied at the rate of 2300 litres per hectare. Any mulch disturbed or displaced following application shall be removed, reseeded and remulched as specified. In case of treatm with Geogrids, Jute netting/Geonetting shall be unrolled and placed parallel to the flow water immediately after bringing, the slope surface to finished grade, the area specified the plans or the placing of seed and fertilizer. Where more than one strip is required to co the given areas, they shall have a minimum overlap of 100 mm. Jute netting/Geonetting s be held in place by approved wire staples, pins, spikes or wooden stakes driven vertic into the soil. The upper and lower ends of the grids shall be secured by anchoring the e into the trenches dug for this purpose and, after anchoring the ends, refilled with the sa material.

### *1610.3.3.6 Maintenance*

The Contractor shall maintain all seeded and mulched areas until final acceptan Maintenance shall include protection of traffic by approved warning signs or barricades a repairing any areas damaged following the seeding and mulching operations. If mulch areas become damaged, the area shall be reshaped and then seeded and mulched again originally specified.

### *1610.3.3.7 Measurements for payment*

Seeding and mulching shall be measured as finished work in square metres.

### *1610.3.3.8 Rate*

The Contract unit rate for seeding and mulching shall be payment in full for carrying out all required operations including full compensation for all materials, labour, tools and incident and maintenance in accordance with the requirements of these specifications.

## 1611 REMOVAL OF LANDSLIDES (SLIP–CLEARANCE)

### 1611.1 Scope

Due to land slides, along disturbed hill slopes, the roadway width for traverse of traffic g reduced specially during monsoons. Immediate removal of slips/debris from the road shall done so as to make full width of road way available to traffic.

### 1611.2 Construction Operations

The debris shall be removed by manual labour (in case of small quantity) and by machin (bull dozer, etc.) in case of large quantities. Since land slides on existing roads do not ha any regular geometrical shape and types and size of debris also varies greatly, as such, contract agreement for removal of road side debris shall be based on lump sum rate cum.

### 1611.3 Measurements for payment

The quantity of debris shall be measured before hand prior to its removal. The debris s be divided into several parts so that each part is somewhat of a regular geometrical sha Quantity of such parts in cubic metres shall be computed on the basis of mean length, me width and mean height. Where the slide mass is largely sloped, it shall be measured as maximum length at road level X maximum width at road level X maximum height from road level X factor 2/9.

### 1611.4 Rate

The contract unit rate for removal of debris shall be payment in full including labour, material, tools and plants, equipment for preparing smooth surface clear of the entire debris by achieving original surface and level of the existing road in accordance with the requirements of these specifications.

## 1612 BIO–ENGINEERING MEASURES IN SLOPE STABILIZATION AND PROTECTION

**1612.1** Bio-engineering measures involving use of living plants shall be undertaken in conjunction with engineering solutions for stabilization and protection of road side slopes against erosion and to improve drainage. Bio-Engineering works would be complementary to civil engineering structures and would normally not replace them. The materials and skills involving execution of bio-engineering measures are available in rural areas. Plants used in bio-engineering would perform one or more of the required functions of anchoring and reinforcing the surface material by extending roots down below into firmer strata, catching erodible material or debris or draining the excess water discharge from the slopes. Plant types and the methodology adopted for the plantation vary in their ability to resolve the various slope stabilization requirements. Hence, selection of the plants and the methodology for their adoption is a vital function for the success of the bio-engineering techniques. Slope failures up to 0.50 m depth are tackled by bio-engineering techniques. Potential failures deeper than this would require adopting big woody plants with large vertical roots. Bio-engineering techniques are not effective for deep seated slope failures. **Figs. 1600.6 to 11** show the various bio-engineering measures applicable for slope stabilization and protection.

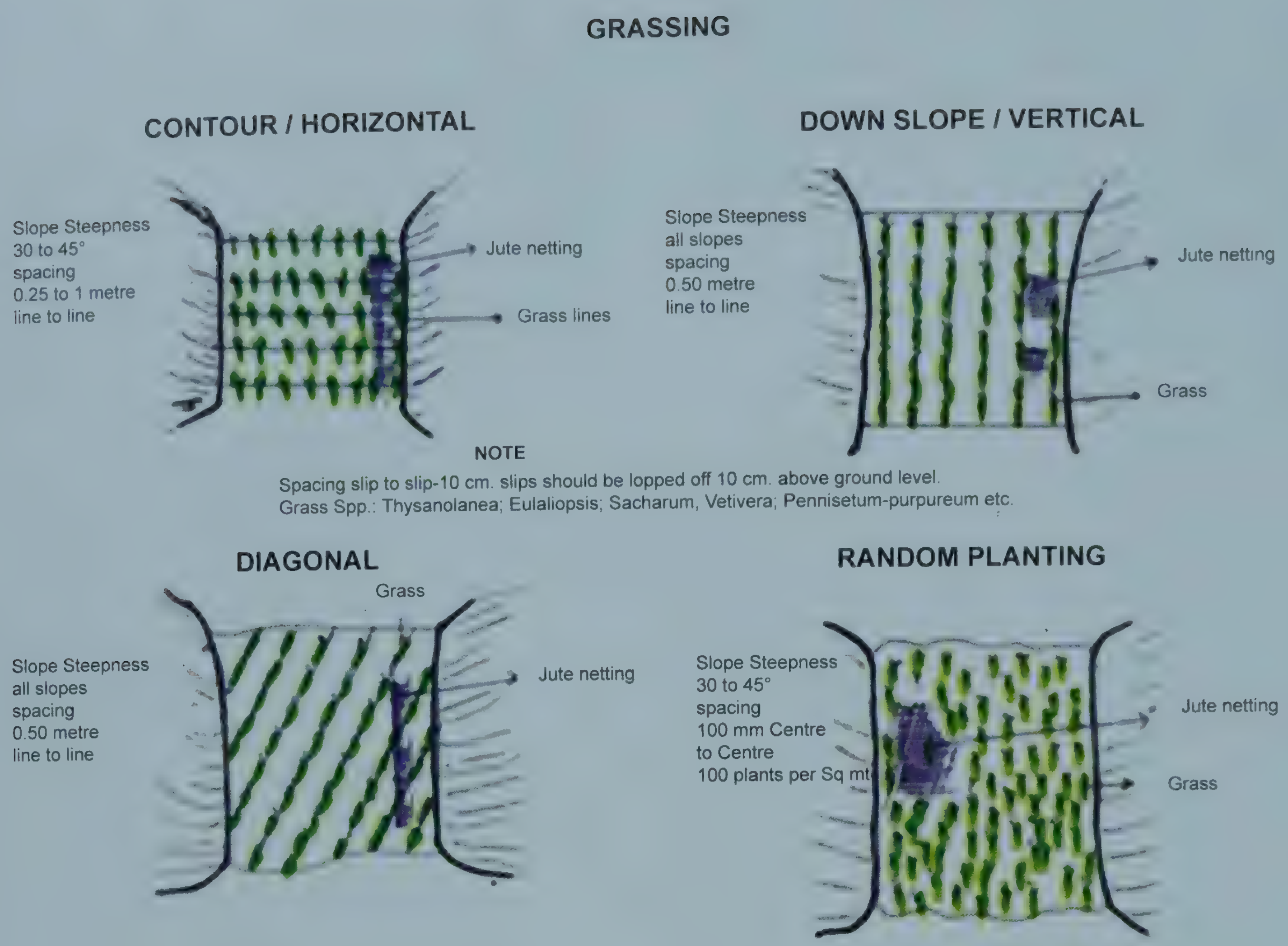
### 1612.2 Slope Preparation

### 1612.2.1 *General*

*1612.2.1.1* The Contractor shall prepare slopes for planting operations as directed by the Engineer. This shall be done according to the specifications described hereunder as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

*1612.2.1.2* In the course of slope preparation works, it is essential that no damage is done to the existing vegetation unless the Engineer's instructions specifically require certain plants to be removed.

*1612.2.1.3* The timing of bio-engineering operations is of critical importance. Activities such as planting shall be carried out within the critical few weeks when they will yield the desired results. All other operations shall be carried out in a timely manner to permit this to happen. The Contractor is responsible for executing the works to the strict time schedule required; and under no circumstances shall he cause delays.


GRASSING
CONTOUR / HORIZONTAL
Slope Steepness
30 to 45°
spacing
0.25 to 1 metre
line to line
Jute netting
Grass lines
DOWN SLOPE / VERTICAL
Slope Steepness
all slopes
spacing
0.50 metre
line to line
Jute netting
Grass
DIAGONAL
Grass
Slope Steepness
all slopes
spacing
0.50 metre
line to line
Jute netting
RANDOM PLANTING
Slope Steepness
30 to 45°
spacing
100 mm Centre
to Centre
100 plants per Sq mt
Jute netting
Grass

NOTE

Spacing slip to slip-10 cm. slips should be lopped off 10 cm. above ground level.
Grass Spp.: Thysanolanea; Eulaliopsis; Sacharum, Vetivera; Pennisetum-purpureum etc.

Fig. 1600.6 Bio-Engineering Techniques (Grassing)

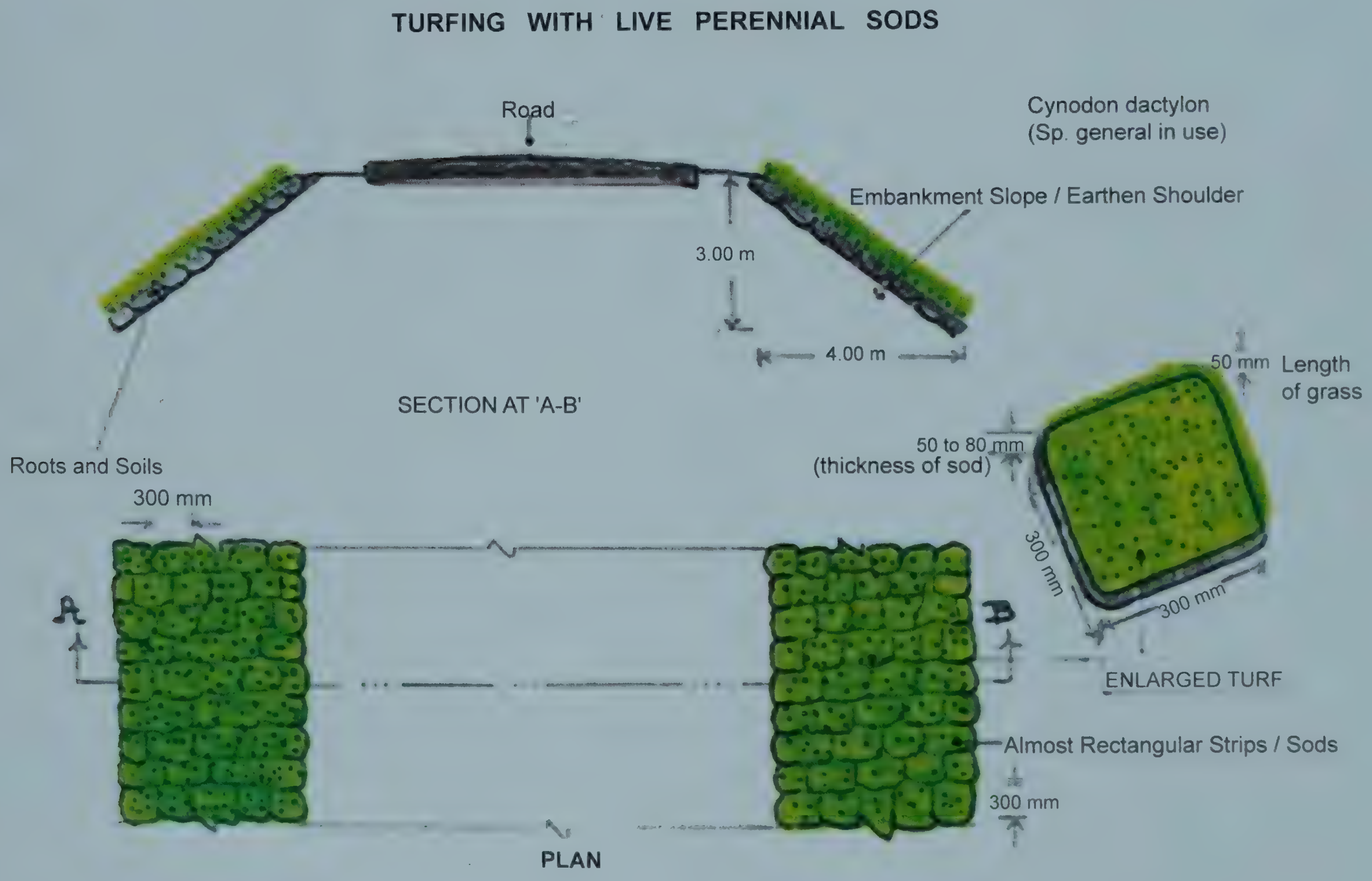
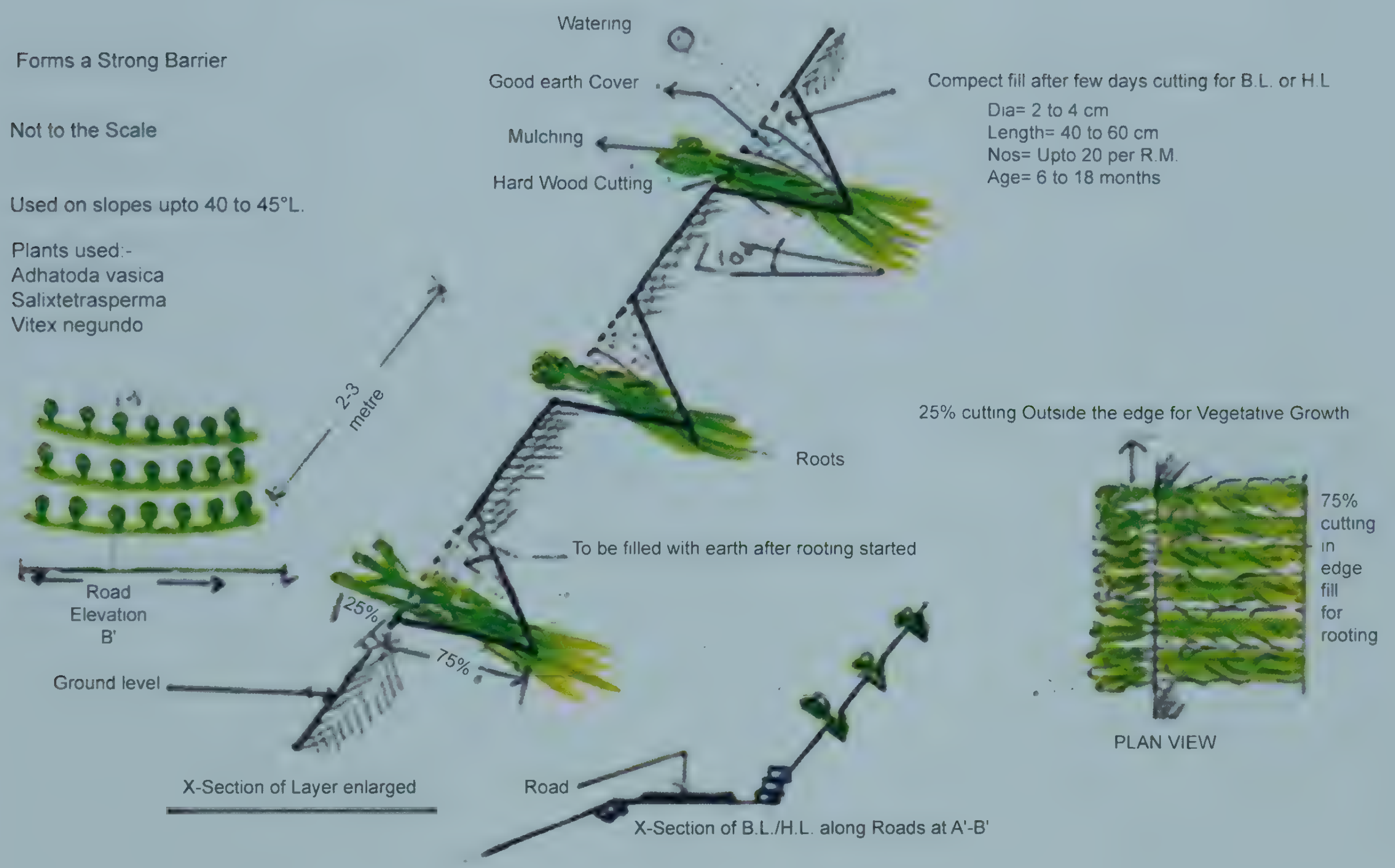

TURFING WITH LIVE PERENNIAL SODS
Road
Cynodon dactylon
(Sp. general in use)
Embankment Slope / Earthen Shoulder
3.00 m
4.00 m
SECTION AT 'A-B'
Roots and Soils
50 mm
Length
of grass
50 to 80 mm
(thickness of sod)
300 mm
300 mm
300 mm
ENLARGED TURF
A
B
Almost Rectangular Strips / Sods
300 mm
PLAN

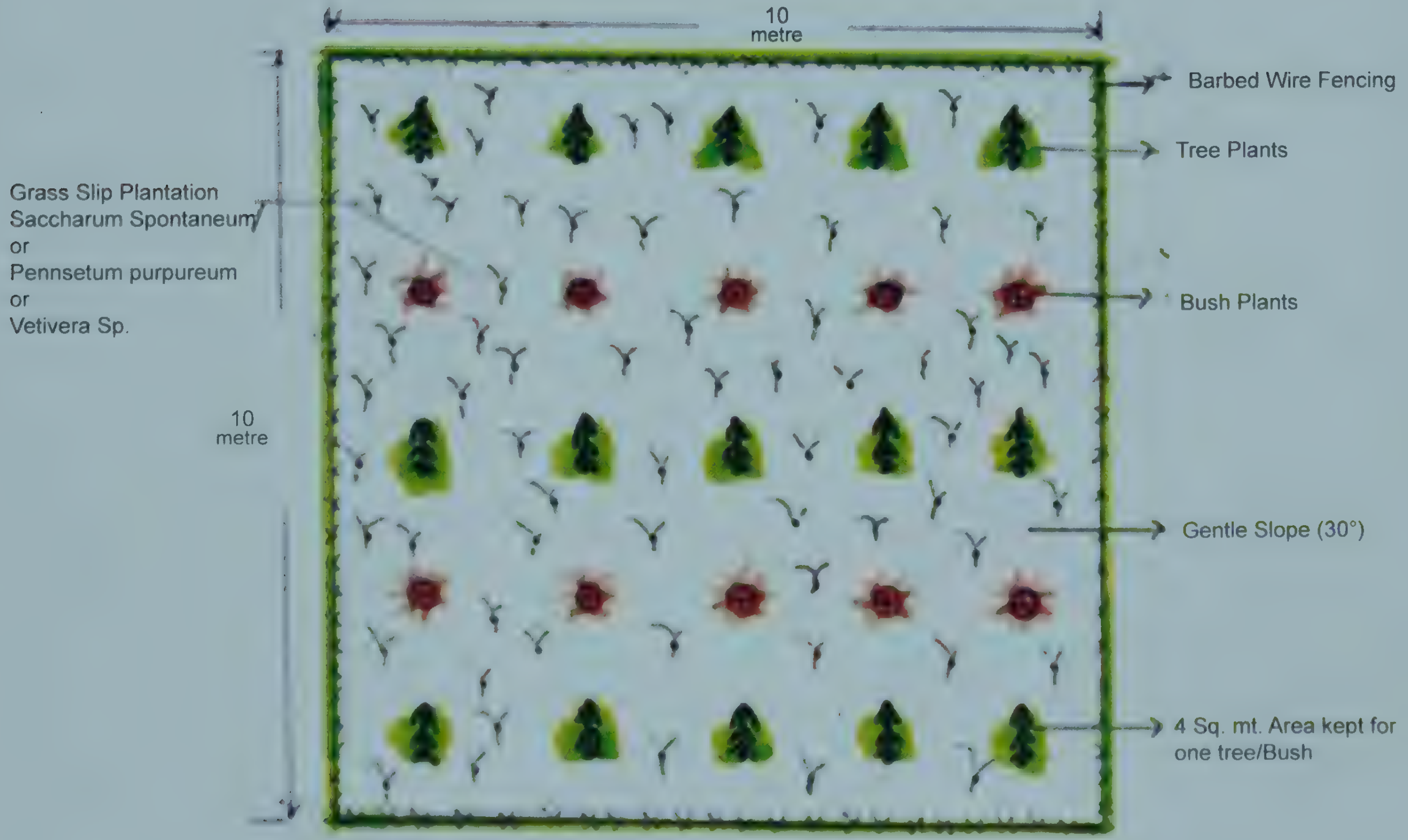
Fig. 1600.7 A Bio-Engineering Technique



BRUSH LAYER / HEDGE LAYER

Forms a Strong Barrier
Not to the Scale
Used on slopes upto 40 to 45°L.
Plants used:-
Adhatoda vasica
Salixtetrasperma
Vitex negundo
Watering
Good earth Cover
Mulching
Hard Wood Cutting
Compect fill after few days cutting for B.L. or H.L
Dia= 2 to 4 cm
Length= 40 to 60 cm
Nos= Upto 20 per R.M.
Age= 6 to 18 months
10°
2-3 metre
Roots
25% cutting Outside the edge for Vegetative Growth
75% cutting in edge fill for rooting
PLAN VIEW
To be filled with earth after rooting started
Road Elevation B'
25%
75%
Ground level
X-Section of Layer enlarged
Road
X-Section of B.L./H.L. along Roads at A'-B'

Fig. 1600.8 Bio-Engineering Technique



TREE AND SHRUB PLANTATION

for Slope Stabilization

10 metre
Barbed Wire Fencing
Tree Plants
Grass Slip Plantation
Saccharum Spontaneum
or
Pennsetum purpureum
or
Vetivera Sp.
Bush Plants
10 metre
Gentle Slope (30°)
4 Sq. mt. Area kept for one tree/Bush

Fig. 1600.9 Bio-Engineering Technique

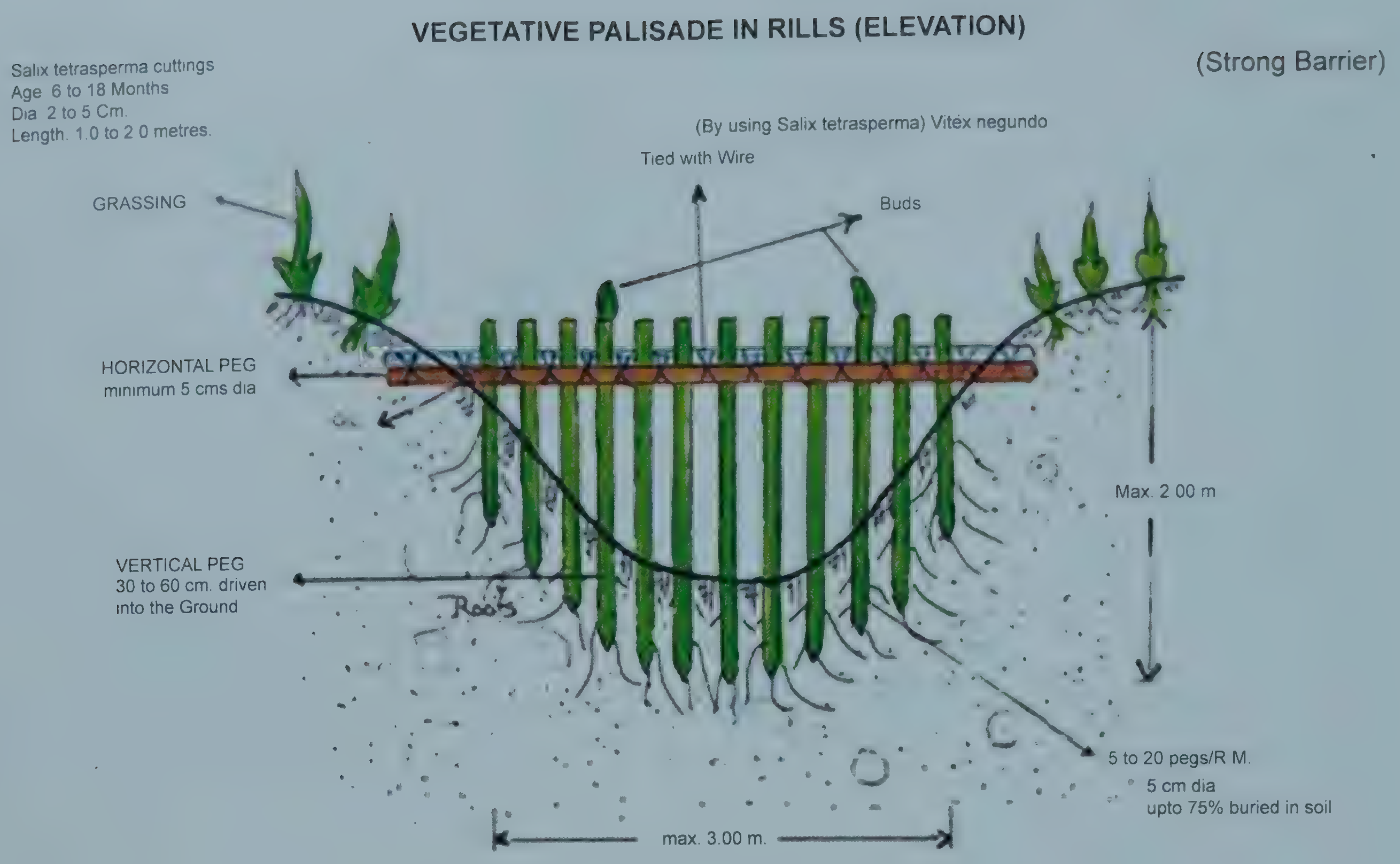

VEGETATIVE PALISADE IN RILLS (ELEVATION)
(Strong Barrier)
Salix tetrasperma cuttings
Age 6 to 18 Months
Dia 2 to 5 Cm.
Length. 1.0 to 2.0 metres.
(By using Salix tetrasperma) Vitex negundo
Tied with Wire
Buds
GRASSING
HORIZONTAL PEG
minimum 5 cms dia
Max. 2.00 m
VERTICAL PEG
30 to 60 cm. driven
into the Ground
Roots
5 to 20 pegs/R M.
5 cm dia
upto 75% buried in soil
max. 3.00 m.

Fig. 1600.10 Bio-Engineering Technique

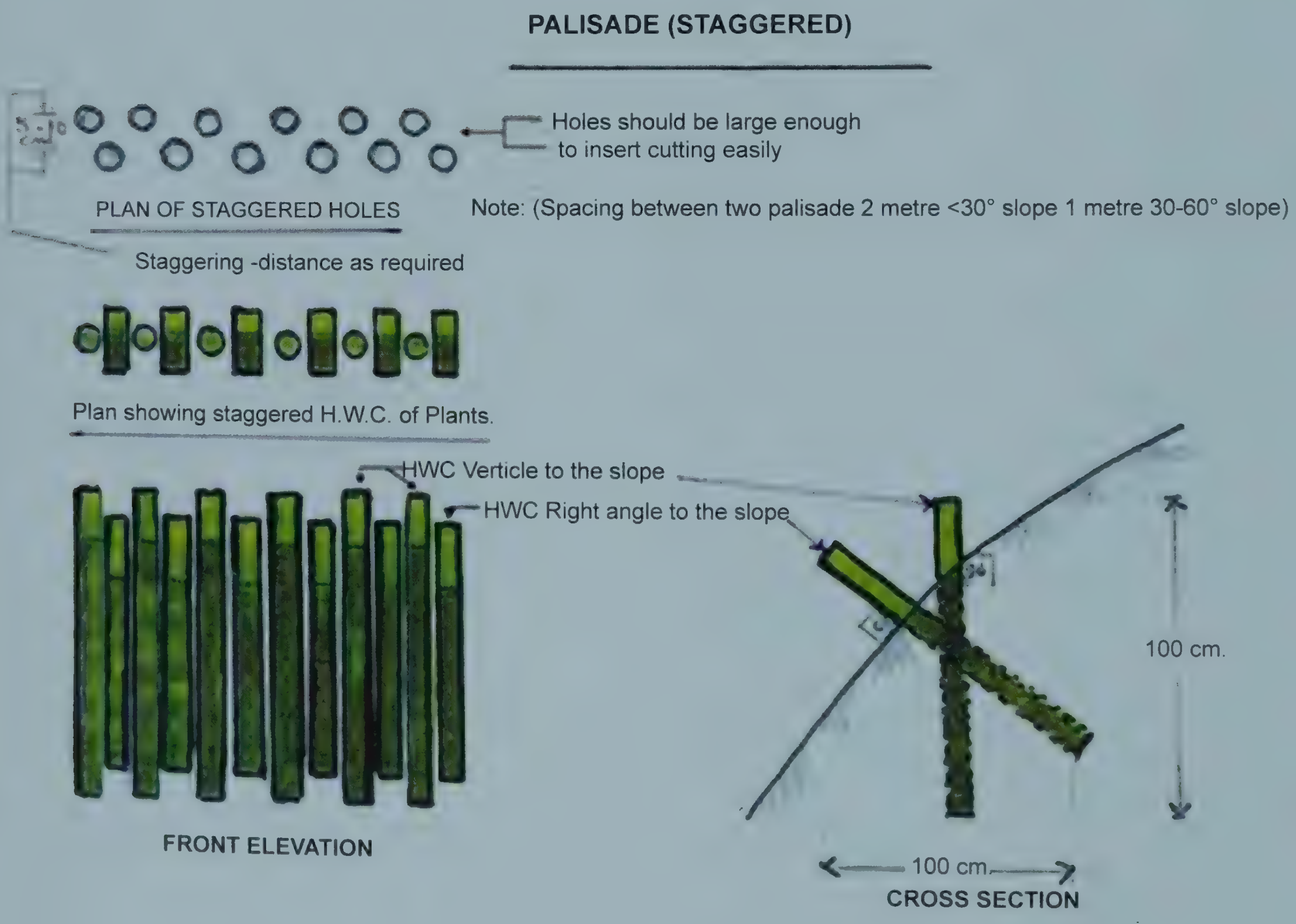

PALISADE (STAGGERED)
Holes should be large enough
to insert cutting easily
PLAN OF STAGGERED HOLES
Note: (Spacing between two palisade 2 metre <30° slope 1 metre 30-60° slope)
Staggering -distance as required
Plan showing staggered H.W.C. of Plants.
HWC Verticle to the slope
HWC Right angle to the slope
FRONT ELEVATION
100 cm.
100 cm.
CROSS SECTION

Fig. 1600.11 A Bio-Engineering Technique

### 1612.2.2 *Final preparation of cut slope for grass planting*

*1612.2.2.1* The purpose of final cut slope preparation is to produce a surface adequately prepared for grass planting. Bio-engineering plants provide a strong surface cover but need a well prepared surface in which to be planted. For vegetation to be an effective form of slope protection, it shall be allowed to establish properly on a slope which does not subject it to undue stress from erosion and mass movement in its initial stages.

1612.2.2.2 The Contractor shall ensure that the slope under instructions is trimmed to a straight angle according to the Engineer's directions. Cut slopes to be planted with grass will normally be 3 vertical: 2 horizontal, but this may be varied at the Engineer's discretion. In any event, a straight profile shall be obtained. Concavities shall be filled with well compacted material. Convexities shall be removed and it is essential that the general profile does not have a shape giving over-steep segments.

### 1612.2.3 *Final preparation of fill slopes for bio-engineering*

*1612.2.3.1* The purpose of the final preparation of fill slopes and slopes comprising unconsolidated land slide debris is to produce a surface adequately prepared for shrub or tree planting or grass sowing, or combination of these. Vegetation is used to provide a strong surface cover but needs a well prepared surface in which to be planted. For it to be an effective form of slope protection, it shall be allowed to establish properly on a slope which does not subject it to undue stress in its initial stages.

*1612.2.3.2* The Contractor shall ensure that the slope is trimmed to a straight angle. In any event, a straight profile must be obtained. All masses of loose debris, especially where it has previously been tipped at the head of the slope, shall be removed. Concavities shall be filled with well compacted material. Convexities shall be removed and it is essential that the general profile does not have a shape giving over-steep segments.

### 1612.2.4 *Measurements for payment*

Measurements for payment of works of earthwork in cut slopes and fill slopes shall be carried out in accordance with the requirements of Section 300 of these Specifications respectively.

### 1612.2.5 *Rate*

The contract unit rates for earthwork in cut slopes and fill slopes shall be in accordance with the requirements of Section 300 of these Specifications.

## 1612.3 Site Planting and Sowing

### 1612.3.1 *Scope*

The Contractor shall plant grass, shrubs and trees as specified in the contract or as directed by the Engineer. This shall be done according to the Specifications described hereunder. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

It is the Contractor's responsibility to ensure that all planting stock is of high quality and vigorous enough to grow on the site at which to be planted.

All planting stock shall be of species indigenous to the area unless otherwise specified. They must be appropriate for the precise site conditions in which they are to be planted and the Contractor shall ensure that they are suitable for the specific altitude and other environmenta characteristics of the site in question.

The timing of bio-engineering operations is of critical importance. Activities such as planting shall be carried out within the critical few weeks when they will yield the desired results. All other operations shall be carried out in a timely manner to permit this to happen. The Contractor is responsible to adhere to the strict time schedule required and under no circumstances shal he cause delays.

### 1612.3.2 *Materials*

### *1612.3.2.1 Plant cuttings*

The species of plants to be collected for vegetative propagation will be as directed by the Engineer. Plants should normally be close to the project working area. The Contractor shal be responsible for collecting the plant material sources.

### *1612.3.2.2 Grass cutting*

Cuttings of various types must be taken from grass species which are known to propagate easily by vegetative means.

Cuttings must be made from as many healthy plants as possible. The plants from which these cuttings are taken must show vigorous growth and good form. Grass clumps showing stunted growth shall not be permissible.

Apart from the clumps which are dug up to make cuttings, the Contractor shall under no circumstances damage other plants. The Contractor is responsible for making all necessary arrangements with land owners, farmers and the local forest office, as applicable, before the excavation of plants to make cuttings.

The types of cuttings to be made depend on the species. **Table 1600.1** gives range of species If the species to be used are not listed here, then the latest technical information provided by the concerned roads agency should be consulted. If the species is still not covered, then stem and root slip cuttings should be used.

**Table 1600.1 Range of Species for Cuttings**

| Common Name | Botanical Name | Best Propagation | Details |
|---|---|---|---|
| Bhabar | Eulaliopsis Binata | Slip cuttings | Stem: 100-150 mm: Root: 30-60 mm |
| | Neyraudia Reynaudiana | Stem/Slip cuttings | Stem cuttings: 2 nodes plus 50mm each side<br>Slips: Stem: 100-150 mm: Root: 30-60 mm |

| | | | |
|---|---|---|---|
| Kans | Saccharum Spontaneum | Slip cuttings | Stem: 100-150 mm<br>Root: 30-60 mm |
| | Themeda Species | Slip cuttings | Stem: 100-150 mm<br>Root: 30-60 mm |
| | Cymbopogon Microtheca | Slip cuttings | Stem: 100-150 mm<br>Root: 30-60 mm |
| Khus | Vetiveria Lawsoni | Slip cuttings | Stem: 100-150 mm<br>Root: 30-60 mm |
| Napier | Pennisetum Purpureum | Stem cuttings | 2 nodes plus 50 mm each side |
| | Arundo Clonax | Stem/slip cuttings | Stem cuttings: 2 nodes plus 50 mm each side<br>Slips: Stem: 100-150 mm: Root: 30-60 mm |
| | Arunduella Nepalensis | Slip cuttings | Stem: 100-150 mm<br>Root: 30-60 mm |
| Sito | Neyraudia Arundinacea | Slip cuttings | Stem: 100-150 mm<br>Root: 30-60 mm |

Where roots are required for cuttings, grass clumps shall carefully be dug up. They shall not be pulled hard as this can damage the material. They shall be separated carefully by hand, using a sharp knife or razor blade when necessary. There shall be no tearing of the plant fabric.

Stem cuttings shall be made using sharp secateurs. The top cut should be made at right-angles to the stem and the bottom cut should be made at 45º to the stem. This is to show the orientation of planting.

Once cuttings have been made, they shall be wrapped in wet hessian jute immediately. At all times, cuttings are to be kept moist and as cool as possible, and shall be wrapped in wet hessian between all operations such as digging out of the ground, splitting out, trimming and planting. Under any circumstances, all cuttings shall be planted the same day that they are made.

### *1612.3.2.3 Hardwood cuttings*

Hardwood cuttings shall only be taken from shrubs and trees or species which are known to propagate easily by vegetative means. Hardwood cuttings are to be used in high rainfall areas. In other areas, rooted plants are to be used.

Cuttings must be made from as many healthy individual plants as possible. The plants from which the cuttings are taken must show vigorous growth and good form. Mis-shapen and stunted plants shall not be permissible.

Apart from the branches from which cuttings are taken, the Contractor shall under no circumstances damage plants while taking cuttings. The Contractor is responsible for making all necessary arrangements with land owners, farmers and local forest office, as applicable before the making of hardwood cuttings. In no case more than 60 percent of the aerial parts of a single plant permitted to be removed in making of cuttings.

Hardwood cuttings shall be made from stems which are between 6 and 18 months ol Materials outside this range are not normally vigorous or strong enough to survive as cutting The Contractor may be held liable if the success rate of cuttings is seriously lower than th normally expected percentage.

Hardwood cuttings must be made using sharp secateurs or a sharp saw. The top of the c should be made at right-angles to the stem and the bottom cut should be made at 45° to th stem. This is to show the orientation of planting. Under no circumstances must there be an damage to the bark of the cutting.

Hardwood cuttings are normally 15 to 40mm in diameter and of the following lengths: 450 600 mm for use in palisades, vegetated stone-pitched walls and for pegging jute netting; 45 to 600 mm for use in brush layers; and a minimum of 1000mm for use in fascines. For use live check dams, all cuttings are to be 2000 mm in length; the cuttings for cross pieces shou be 20 to 50 mm in diameter and the truncheon cuttings for the vertical elements shou be 30 to 80 mm in diameter: truncheon cuttings are made only from the species known be propagated by farmers using this method. These sizes should not be exceeded unle specified by the Engineer.

A number of species can be propagated using large truncheon cuttings. Hardwood cuttin for these species should be in the range of 1500 to 2500 mm in length and 30 to 80 mm diameter unless otherwise specified.

Once cuttings have been made, they shall be wrapped in wet hessian jute immediately. At times, cuttings are to be kept moist and as cool as possible, and should be wrapped in w hessian between all operations such as taking from the parent plant, trimming and plantin Under any circumstances, all cuttings shall be planted the same day that they are made.

### **1612.3.3** *Planting of grass slips and cuttings*

#### *1612.3.3.1 Scope*

The planting of grass slips and cuttings is intended to create a strengthened slope surfa which is resistant to erosion. The Contractor is required to carry out the planting of gra seedlings or rooted cuttings according to the Engineer's directions. The configuration planting will be determined according to individual site conditions. It will be either rando contoured, diagonal or down slope.

#### *1612.3.3.2 Preparation*

The site shall already have been prepared for planting. Further, the Contractor shall ensu that the condition of the site is good enough for the successful establishment of the grass and accords with Clause 1612.2 of these Specifications.

#### *1612.3.3.3 Construction*

Using appropriate tools such as tape measures and spirit levels, planting lines shall be mark out with string as required. Unless specified otherwise by the Engineer, the row spacing to be marked out shall be as per **Table 1600.2**.

**Table 1600.2 Row Spacing**

| Planting Configuration | Slope Angle | Row Spacing |
|---|---|---|
| Random | Slope less than 30 degrees | 1000 mm centres |
| | Slope 30 to 45 degrees | 500 mm centres |
| | Slope more than 45 degrees | 250 mm centres |
| Contour lines | Slope less than 30 degrees | 1000 mm centres |
| | Slope 30 to 45 degrees | 500 mm centres |
| | Slope more than 45 degrees | 250 mm centres |
| Diagonal lines | All slopes | 500 mm centres |
| Downslope lines | All slopes | 500 mm centres |

The Contractor shall supervise all field operations closely. The planting of grass slip is a delicate business and should be approached in the same way as the transplanting of millet seedlings. The Contractor shall engage experienced agricultural labour for this work.

The plants supplied should be prepared for planting as indicated here. The Contractor shall transport the plants wrapped in hessian jute. At all times, plants are to be kept moist and as cool as possible, and shall be wrapped in wet hessian between all operations such as their extraction, final preparation and planting. Under any circumstances, all plants supplied shall be planted the same day that they are lifted.

Grass slips or cuttings should be carefully separated from the clumps to give the maximum viable planting material. Any roots in excess of 25 mm should be cut off using a sharp knife or razor blade. Shoots and stems should be lopped off 100 mm above the ground. This can, however, be increased for large grasses.

In case normal type grassing with slips of large grasses is used, this would require planting slips @3 slips per hole. However, in case grassing with large grasses (large rhizomatous type like small bamboos) or grassing with unrooted stem cuttings of heavy branching type grasses is used, in that case only single slip per hole would be required.

Planting shall be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed.Using a small bar (usually made of mild steel with a flattened end), a hole shall be made that is just big enough for the roots. The slip or cutting is inserted; care shall be taken that the roots are not tangled or bent back to the surface. Soil is then replaced around the roots and firmed with the fingers. The spacing of plants within rows shall be 100 mm unless otherwise specified.

If the soil is dry and there is no rain within 16 to 24 hours of planting, the site shall be watered carefully with a fine spray. The Contractor shall water for the first two weeks after planting in the event of inadequate rainfall.

### **1612.3.4** *Planting of hardwood cuttings*

#### *1612.3.4.1 Scope*

Certain trees and shrubs can be planted on site by means of hardwood cuttings. These cuttings are to be used in high rainfall areas. When these cuttings are specified, the Contractor is required to carry out the planting of cuttings as directed by the Engineer.

#### *1612.3.4.2 Preparation*

The site shall have been prepared for planting. Further, the Contractor shall ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

The Contractor shall supervise all field operations closely. The planting of trees and shrub cuttings is a delicate business and should be approached in the same way as the planting of horticulture cuttings (e.g. those of tea). The Contractor shall engage experienced agricultural or forestry labour for this work.

The cuttings are normally to be made as per Clause 1612.3.2.3 of these Specifications. The Contractor is to collect the cuttings and transport them wrapped in hessian jute. At all times, cuttings are to be kept moist and as cool as possible and shall be wrapped in wet hessian between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied shall be planted the same day that they are lifted from their source.

#### *1612.3.4.3 Construction*

The spacing of hardwood cuttings will be determined according to individual site conditions. However, it will normally be at 500 mm centres unless otherwise specified.

Planting shall be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a flattened end), a hole should be made that is just big enough for the cutting. The cutting is inserted and the soil is replaced around it and firmed with the fingers. The cutting should be inserted to a depth such that two-thirds to three-quarters of it is buried.

Where rooted cuttings have been supplied from a nursery, they must be planted in such a way that the roots are not damaged or badly bunched in the planting hole. The hole must be big enough to take the roots so that they are properly spaced out all around the plants.

If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should be watered carefully with a fine spray. The Contractor shall water for the first two weeks after planting in the event of inadequate rainfall.

The Engineer may specify bigger cuttings for specific area, using large truncheon cuttings. Under no circumstances should these cuttings be hammered into the ground.

### **1612.3.5** *Brush layering, palisades and fascines*

#### *1612.3.5.1 Scope*

In certain situations, the Contractor will be required to construct vegetation structures using hardwood cuttings.

Brush layering is a technique whereby woody (or hardwood) cuttings are laid in shallow trenches aligned across the slope, usually following the contour. These form a strong barrier, preventing erosion and the development of rills, and trap material moving down the slope. In the long term, a small terrace will develop. The main engineering functions are to catch debris, and to armour and reinforce the slope. In certain locations, brush layers can be angled to provide a drainage function.

Palisades are similar to brush layers, except that the cuttings are inserted directly into the soil upright, rather than being laid into shallow trenches. Palisades are quicker to install and easier in rocky sides, but there is usually a far more limited growth success rate than for brush layers.

The word “fascine” means a bundle of sticks. In this technique, bundles of live branches are laid in shallow trenches. After burial in the trenches, they put out roots and shoots, forming a strong line of vegetation. It is sometimes called live contour wattling. The main engineering functions are to catch debris, and to armour and reinforce the slope. In certain locations, fascines can be angled to provide drainage. Where time is a premium, brush layers may be more appropriate as these are quicker to establish than fascines.

It is the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

### *1612.3.5.2 Materials*

The cuttings arranged by the Contractor should be ready for planting. Normally, they should be at least 450 mm long for brush layering, 600 mm long for palisades and 1000 mm long for fascines. The Contractor is to collect the cuttings and transport them wrapped in hessian jute. At all times, cuttings are to be kept moist and as cool as possible and shall be wrapped in wet hessian between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied shall be planted the same day that they are lifted from their source.

The Engineer will specify the species and expected sources and the Contractor shall accordingly procure the cuttings. This will be done in the manner described in these Specifications Clause 1612.3.2.3 except that the size of cuttings will be of a minimum length of 600 mm for brush layering on land slide debris, 450 mm for brush layering on road embankments, 600 mm for palisades and 1000 mm for fascines, and minimum diameter of 30 mm for brush layering, 40 mm for palisades and 50 mm for fascines.

The species that can be used for these purposes are as under:

1) Jatropha hastate (Diesel Plant)
2) Morus Papyrifera (Paper Mulberry)
3) Morus Alba (Mulberry)
4) Platinus Orientalis (Chinar)
5) Salix Alba (Willow)

6) Salix Tetrasperma (Majnoo)
7) Salix Babilonica (Majnoo)
8) Vitex Negundo (Shamalu)
9) Sapium Insigne (Balojo)
10) Euphorbia Royleana (Thoor)
11) Ipomea Batata (Ipomea)

The species used must be appropriate for the precise site conditions, altitude, should be indigenous species and should be suitable for other environmental characteristics of the site. Deciduous species are used for the construction of palisades and fascines during winter season whereas evergreen species are used during rainy season construction. Use of fast growing species should be made so that the same is rapidly established along the destabilized slopes.

### *1612.3.5.3 Construction*

The Contractor shall supervise all field operations closely. The planting of tree and shrub cuttings is a delicate business and should be approached in the same way as the planting of horticulture cuttings (e.g. those of tea). The Contractor shall engage experienced agricultural or forestry labour for this work.

Planting should always be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed.

### *1612.3.5.4 Brush layering*

Brush layering should be constructed as given here, unless specified otherwise.

i) Starting at the bottom of the area to be treated and using appropriate measuring equipment exact lines should be marked out. From one metre above the bottom of the slope, a precise contour line should be marked out every one metre up the slope.

ii) Terraces approximately 450 mm wide on landslide debris or 350 mm on road embankments should be excavated along the lines.

iii) Cuttings should then be placed into each trench at 50 mm centres, the correct way up and angled so that they are at right-angles to the maximum slope angle. All cuttings should be inserted to a depth such that 2/3 to 3/4 of their length is buried.

iv) The trench should then be partially backfilled and another line of cuttings placed along the trench at 50 mm centres and 100 mm behind the first line, and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line. This results in cuttings at 25 mm centres in every brush layers (that is 40 cuttings per running metre). The trench is then completely backfilled and gently compacted. Any loose or excess material is cleared down the slope before the next line is planted.

v) In some cases, it will be specified that cuttings should be placed in a criss-cross fashion. Where this is to be done, one layer of cuttings is laid in the trench at 30 degrees to one side of the line of maximum fall of slope. A second layer of cuttings is laid on top of this, at 30 degrees to the other side of the line of maximum fall of slope. Backfilling and compaction are then completed.

### *1612.3.5.5 Palisades*

Palisades should be constructed as given here, unless specified otherwise.

i) Starting at the top of the area to be treated and using appropriate measuring equipment exact lines should be marked out. From one metre below the top of the slope, a precise contour line should be marked out every one metre down the slope.

ii) Starting at the end and using a small bar (usually made of mild steel and with a flattened end) a hole should be made that is just big enough for the first cutting. The cutting is inserted and the soil is replaced around it and firmed with the fingers. The cutting must be the correct way up and angled so that it is vertical. The cutting should be inserted to a depth such that 2/3 to 3/4 of it is buried.

iii) The process should be repeated along the entire line, with a series of cuttings placed at 50 mm centres.

iv) If a double line is specified, then a second line of cuttings must be placed in the same way, 100 mm behind the first and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line.

v) The soil around the single or double line is then completely backfilled into any remaining gaps and gently compacted. Any loose or excess material is cleared down the slope before the next line is planted.

### *1612.3.5.6 Fascines*

Fascines are bundles of hardwood cuttings laid horizontally in trenches, and parallel to the line of the trench. The bundles are thereby completely buried. Fascines should be constructed as given here, unless specified otherwise.

i) Starting at the bottom of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out. From one metre above the bottom of the slope, a precise contour line should be marked out every one metre up the slope.

ii) Starting at the bottom, trenches approximately 200mm in depth should be excavated along the lines.

iii) Cuttings should then be laid along each trench, so that they li horizontally along the trench. There should normally be eight cutting together, although where material is short, a minimum of four cuttings i permissible. They must be overlapped so that no two ends coincide. Th cuttings must then be tied using jute or coir string at 500mm intervals t form a bundle. As the fascine is created, it thereby forms a continuou bundle right across the slope.

iv) The trench should then be backfilled and gently compacted. The to of the fascine should be 50 to 100 mm below the surface. Any loos or excess material is cleared down the slope before the next line i planted.

The Engineer may specify that orientations other than along the contour of the slope ar used. In such an event, the Contractor shall alter the laying out of lines accordingly and mee the precise angle required.

If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should b watered carefully with a fine spray. The Contractor shall water for the first two weeks afte planting in the event of inadequate rainfall.

### 1612.3.6 *Measurement for payment*

Bio-engineering works shall be measured as finished work in units indicated below:

| | | |
|---|---|---|
| i) | Provision of hardwood cuttings | Number of cuttings |
| ii) | Planting of grass slips and cuttings | sqm |
| iii) | Planting of hardwood cuttings | sqm |
| iv) | Construction of brush layers, palisades and fascines | linear m |

### 1612.3.7 *Rate*

The contract unit rate for all bio-engineering works shall be payment in full for carrying out a the required operations including full compensation for all materials, labour, tools, equipmen and incidentals and shall include all leads and lifts in accordance with these specifications.

## 1700

# TRAFFIC SIGNS, MARKINGS AND OTHER ROAD APPURTENANCES

# 1701 TRAFFIC SIGNS

## 1701.1 Scope

The work shall cover fabrication, supply and installation of traffic signs conforming to the Code of Practice for Road Signs, IRC:67 complete in all respects in accordance with these Specifications and as approved by the Engineer.

## 1701.2 General

**1701.2.1** The colour, configuration, size , dimensions and location of all traffic signs for roads shall be in accordance with the Code of Practice for Road Signs, IRC:67, or as shown on the drawings. In the absence of any details or for any missing details, the same shall be provided as directed by the Engineer.

**1701.2.2** The signs shall be,as shown on the drawings, fixed over Aluminium Composite Material (ACM) as per Clause 1701.3.7 and reflective sheeting as per Clause 1701.3.8 of these Specifications.

**1701.2.3** Cautionary/warning and mandatory signs will be fabricated through process of screen printing. In case the facility is not locally available in the region of work, these signs and informatory signs may have inscription/message having cut letters of non-reflective black sheeting which shall be bonded well or the base sheeting as directed by the Engineer.

**1701.2.4** Language of inscription and font size for informatory signs shall be in accordance with IRC:67.

**1701.2.5** The informatory signs in respect of rural roads under the PMGSY shall have prescribed diamond type logo (600 mm x 600 mm) of Pradhan Mantri Gram Sadak Yojana on top of sign board.

The specifications and design of typical PMGSY Informatory sign board shall be as given in ***Annexure-1700.1*** of these Specifications and duly approved by the Engineer.

## 1701.3 Materials

The various materials and fabrication of the traffic signs shall conform to the following requirements:-

### 1701.3.1 *Concrete*

Concrete for footing shall be of the grade shown on the Contract drawings or of minimum M15 grade conforming to Section 800 of these Specifications.

### 1701.3.2 *Reinforcing steel*

Reinforcing steel shall conform to the requirement of IS:1786 unless otherwise shown on the drawings.

### 1701.3.3 *Bolts, nuts, washers*

High strength bolts shall conform to IS:1367, whereas precision bolts, nuts shall conform to IS:1364.

### 1701.3.4 *M S Sheets, plates and supports*

Plates and support sections for the sign posts shall conform to IS:226 and IS:2062 or any other relevant IS Specifications.

### 1701.3.5 *Reflectorised paint*

Reflectorised paint shall conform to IS:5 or the manufacturer's specifications in case of proprietary product and as approved by the Engineer.

### 1701.3.6 *Non reflectorised paint*

Non-reflectorised paint shall conform to IS:164 and as approved by the Engineer.

### 1701.3.7 Substrate

Aluminium Composite Materials (ACM)

ACM sheets used for sign boards is a sandwiched construction with a thermoplastic core of 'Low Density Polyethylene' (LDPE) between two skins/sheets of Aluminium with overall thickness of 3 mm. The thickness of each Aluminium skin will be 0.25-0.3 mm on both sides. The mechanical properties of 3 mm ACM and that of its Aluminum skin shall conform to the requirements given in **Table 1700.1**, when tested in accordance with the test methods mentioned against each of them.

**Table 1700.1 Specifications for Aluminium Composite Material**

| S. No. | Description | Specification | |
|---|---|---|---|
| | | Standard Test | Acceptable Value |
| A | **Mechanical Properties of ACM** | | |
| 1) | Peel off strength with retro reflective sheeting. (Drum Peel Test) | ASTM D 903 | Min. 4 N/mm |
| 2) | Tensile strength | ASTM E 638 | Min. 30 N/mm$^2$ |
| 3) | 0.2% Proof Stress | ASTM E 638 | Min. 34 N/mm$^2$ |
| 4) | Elongation | ASTM E 638 | Min. 5% |
| 5) | Flexural strength | ASTM C 393 | Min.120 N/mm$^2$ |
| 6) | Shear strength with Punch shear test | ASTM D 732 | Min.18 N/mm$^2$ |
| B | **Properties of Aluminium Skin** | | |
| 1) | Tensile strength (Rm) | ASTM E8 | Min.130 N/mm$^2$ |
| 2) | Modulus of elasticity | ASTM E8 | Min. 70,000 N/mm$^2$ |
| 3) | Elongation | ASTM E8 | A50 Min. 2% |
| 4) | 0.2 % Proof Stress | ASTM E8 | Min. 110 N/mm$^2$ |

### 1701.3.8 *Retro reflective sheeting*

The retro reflective sheeting used on the signs shall consist of white or coloured sheeting having a smooth outer surface which has the property of retro reflection over its entire surface. It shall be weather resistant and exhibit colour fastness. It shall be new and unused and show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for coefficient of retro reflection, day/night time colour and luminance, shrinkage, flexibility, liner removal, adhesion, impact resistance, specular gloss and fungus resistance ,three years outdoor weathering and its having passed these tests shall be obtained from International/ Government Laboratory/Institute by the manufacturer of the sheeting. For rural roads, retro reflective sheeting is recommended under two classes as follows :

**CLASS A SHEETING: -** Engineering and Super Engineering Grade sheeting as per ASTM D 4956-09 Type I and II.

**CLASS B SHEETING: -** High Intensity and High Intensity Prismatic grade sheeting as per ASTM D 4956-09 Type III and IV.

Type I, II, and III sheeting is now available both as glass beaded and microprismatic technology. The light reflecting efficiency of glass beaded sheeting is lower than the microprismatic sheeting.

The type of sheeting between classes or within a class shall be as specified in the contract or as directed by the Engineer.

*1701.3.8.1 Class A (Engineering Grade Sheetings)*

a) **Type I Engineering Grade Sheeting :** This sheeting shall be enclosed lens type consisting of microscopic lens elements embedded beneath the surface of a smooth, flexible, transparent, water-proof plastic, resulting in a non-exposed lens optical reflecting system. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum coefficient of retro-reflection (determined in accordance with ASTM D 4956-09 Standard) as indicated in **Table 1700.2**.

**Table 1700.2 Acceptable Minimum Coefficient of Retro-Reflection for Engineering Grade Sheeting Type- I (Candel as Per Lux Per Square Metre)**

| Observation Angle | Entrance Angle | White | Yellow | Orange | Green | Red | Blue | Brown |
|---|---|---|---|---|---|---|---|---|
| 0.2° | - 4° | 70 | 50 | 25 | 9.0 | 14.0 | 4.0 | 1.0 |
| 0.2° | +30° | 30 | 22 | 7 | 3.5 | 6.0 | 1.7 | 0.3 |
| 0.5° | - 4° | 30 | 25 | 13 | 4.5 | 7.5 | 2.0 | 0.3 |
| 0.5° | +30° | 15 | 13 | 4 | 2.2 | 3.0 | 0.8 | 0.2 |

When totally wet, the sheeting shall show not less than 90 percent of the values of retro-reflection indicated in **Table 1700.2**. At the end of 5 years, the sheeting shall retain at least 50 percent of its original retro-reflectance.

b) **Type II Super Engineering Grade Sheeting :** This sheeting shall be of enclosed lens glass bead type consisting of microscopic lens elements embedded beneath the surface of a smooth, flexible, transparent, water-proof plastic, resulting in a non-exposed lens optical reflecting system. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum coefficient of retro-reflection (determined in accordance with ASTM D 4956-09) as indicated in **Table 1700.3**.

**Table 1700.3 Acceptable Minimum Coefficient of Retro-Reflection for Type II Super Engineering Grade Sheeting (Candel as Per Lux Per Square Metre)**

| Observation Angle | Entrance Angle | White | Yellow | Orange | Green | Red | Blue | Brown |
|---|---|---|---|---|---|---|---|---|
| 0.2° | -4° | 140 | 100 | 60 | 30 | 30 | 10 | 5 |
| 0.2° | +30° | 60 | 36 | 22 | 10 | 12 | 4 | 2 |
| 0.5° | -4° | 50 | 33 | 20 | 9 | 10 | 3 | 2 |
| 0.5° | +30° | 28 | 20 | 12 | 6 | 6 | 2 | 1 |

When totally wet, the sheeting shall show not less than 90 percent of the values of retro-reflection indicated in above **Table 1700.3**. At the end of 5 years, the sheeting shall retain at least 50 percent of its original retro-reflectance.

*1701.3.8.2* *Class B (High Intensity Grade Sheeting)*

a) **Type III High Intensity Grade :** This high intensity retro reflective sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent water proof plastic having a smooth surface or as an unmetalized micro prismatic reflective material element. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D 4956-09) as indicated in **Table 1700.4**.

When totally wet, the sheeting shall show not less than 90 percent, of the values of retro reflectance indicated in above **Table 1700.4**. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

### Table 1700.4 Acceptable Minimum Coefficient of Retro-reflection for Type III High Intensity Grade Sheeting[A] (Encapsulated Lens Type) (Candelas Per Lux Per Square Metre)

| Observation Angle | Entrance Angle | White | Yellow | Orange | Green | Red | Blue | Brown |
|---|---|---|---|---|---|---|---|---|
| 0.1°[B] | -4° | 300 | 200 | 120 | 54 | 54 | 24 | 14 |
| 0.1°[B] | +30° | 180 | 120 | 72 | 32 | 32 | 14 | 10 |
| 0.2° | -4° | 250 | 170 | 100 | 45 | 45 | 20 | 12 |
| 0.2° | +30° | 150 | 100 | 60 | 25 | 25 | 11 | 8.5 |
| 0.5° | -4° | 95 | 62 | 30 | 15 | 15 | 7.5 | 5.0 |
| 0.5° | +30° | 65 | 45 | 25 | 10 | 10 | 5.0 | 3.5 |

[A] Minimum Coefficient of Retro reflection ($R_A$) (cd.lx$^{-1}$.m$^{-2}$).

[B] Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

b) **Type IV High Intensity Micro-Prismatic Grade Sheeting :** This sheeting shall be of high intensity retro-reflective sheeting made of micro-prismatic retro-reflective element material coated with pressure sensitive adhesive. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D 4956-09) as indicated in **Table 1700.5**.

### Table 1700.5 Acceptable Minimum Coefficient of Retro-Reflection for Type IV High Intensity Micro-Prismatic Grade Sheeting[A] (Candelas per Lux per Square Meter)

| Observation Angle | Entrance Angle | White | Yellow | Orange | Green | Red | Blue | Brown |
|---|---|---|---|---|---|---|---|---|
| 0.1°[B] | -4° | 500 | 380 | 200 | 70 | 90 | 42 | 25 |
| 0.1°[B] | +30° | 240 | 175 | 94 | 32 | 42 | 20 | 12 |
| 0.2° | -4° | 360 | 270 | 145 | 50 | 65 | 30 | 18 |
| 0.2° | +30° | 170 | 135 | 68 | 25 | 30 | 14 | 8.5 |
| 0.5° | -4° | 150 | 110 | 60 | 21 | 27 | 13 | 7.5 |
| 0.5° | +30° | 72 | 54 | 28 | 10 | 13 | 6 | 3.5 |

[A] Minimum Coefficient of Retro reflection ($R_A$) (cd.lx$^{-1}$.m$^{-2}$).

[B] Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above **Table 1700.5**. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

### 1701.3.9 *Plate thickness*

Shoulder mounted ground signs with a maximum side dimension not exceeding 600 mm shall be not less than 3 mm thick with Aluminum Composite Material. Its support shall be such that it does not bend or deform under prevailing wind and other loads. All overhead signs made with Aluminum Composite Material shall be minimum 4 mm thick to withstand wind and other loads without deformation.

**1701.3.10** In respect of sign sizes not covered by IRC:67, the structural details (thickness, etc.) shall be as per the approved drawings or as directed by the Engineer.

### 1701.4 Installation

**1701.4.1** Sign posts, their foundations and sign mountings shall be so constructed as to hold these in a proper and permanent position against the normal storm wind loads or displacement by vandalism. Normally, signs with an area upto 0.9 square metre shall be mounted on a single post and for greater area, two or more supports shall be provided. Sign supports may be of mild steel, reinforced concrete or Galvanised Iron (GI) posts and should be firmly fixed to the ground by means of properly designed foundation. The work of foundation shall conform to relevant Specifications as specified.

**1701.4.2** All components of signs and supports, other than the reflective portion and GI posts shall be thoroughly de-scaled, cleaned, primed and painted with two coats of epoxy paint. Any part of mild steel (MS) post below ground shall be painted with three coats of red lead paint.

**1701.4.3** The signs shall be fixed to the posts by welding in the case of steel posts and by bolts and washers of suitable size in the case of reinforced concrete or GI posts. After the nuts have been tightened, the tails of the bolts shall be furred over with a hammer to prevent removal.

### 1701.4.4 *Adhesives*

The sheeting shall have a pressure-sensitive adhesive of the aggressive-tack type requiring no heat, solvent or other preparation for adhesion to a smooth clean surface, in a manner recommended by the sheeting manufacturer. The adhesive shall be protected by an easily removable liner (removable by peeling without soaking in water or other solvent) and shall be suitable for the type of material of the base plate used for the sign. The adhesive shall form a durable bond to smooth, corrosion and weather resistant surface of the base plate such that it shall not be possible to remove the sheeting from the sign base in one piece by use of sharp instrument. The sheeting shall be applied in accordance with the manufacturer's specifications.

### 1701.4.5 *Fabrication*

Surface to be reflectorised shall be effectively prepared to receive the retro-reflective sheeting. The aluminum composite material sheeting shall be de-greased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth plain surface before the application of retro-reflective sheeting. If the surface is rough, approved surface primer may be used. After cleaning, metal shall not be handled, except by suitable device or clean canvas gloves, between all cleaning and preparation, operation and application of reflective sheeting/primer. There shall be no opportunity for metal to come in contact with grease, oil or other contaminants prior to the application of retro-reflective sheeting. Complete sheets of the material shall be used on the signs except where it is unavoidable. At splices, sheeting with pressure-sensitive adhesives shall be overlapped not less than 5 mm. Where screen printing with transparent colours is proposed, only butt joint shall be used. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds. Cut-outs to produce legends and borders shall be bonded with the sheeting in the manner specified by the manufacturer.

### 1701.4.6 *Messages/Borders*

The messages (legends, letters, numerals, etc.) and borders shall either be screen-printed or of cut out from durable transparent overlay or cut out from the same type of reflective sheeting for the cautionary/mandatory sign boards. Screen printing shall be processed and finished with materials and in a manner specified by the sheeting manufacturer. For the informatory and other sign boards, the messages (legends, letters, numerals etc.) and borders shall be cut out from durable transparent overlay film or cut-out from the same reflective sheeting only. Cut-outs shall be from durable transparent overlay materials as specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer. Cut-out messages and borders, wherever used, shall be either made out of retro-reflective sheeting or made out of durable transparent overlay except those in black which shall be of non-reflective sheeting or opaque in case of durable transparent overlay.

## 1701.5 Warranty and Durability

Both the screen printed areas and cut-out sheeting and cut out durable transparent overlay film shall be covered under the 5 year warranty for Class A sheeting and 7 year warranty for Class B sheeting ,issued by the sheeting manufacturer.

## 1701.6 Measurements for Payment

The measurement of standard cautionary, mandatory and informatory signs shall be in numbers of different types of signs supplied and fixed, while for direction and place identification signs, these shall be measured by area in square metres.

### 1701.7 Rate

The Contract unit rate shall be payment in full for the cost of making the road sign including all labour, materials and installing it at the site, furnishing of necessary test certificates, warranty and incidentals to complete the work in accordance with these Specifications.

## 1702 ROAD MARKINGS

### 1702.1 Scope

The work shall consist of providing road markings at site including supply of materials and carrying out the work in accordance with IRC:35 and these Specifications.

### 1702.2 General

The colour, width and layout of road markings shall be in accordance with the Code of Practice for Road Markings IRC:35 and as specified in the drawings or as directed by the Engineer. No centre line marking shall be done on single-lane roads.

### 1702.3 Materials

Ordinary paints shall be used for road markings, conforming to IS:164. These shall have a wear resistance of at least 4 hours under accelerated laboratory test. Yellow colour (conforming to IS colour No. 356) as given in IS:164, white and black colours are the standard colours used for markings.

### 1702.4. Application

**1702.4.1** Painting may be done by machine or by hand (preferably by machine). The Contractor shall maintain traffic control while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

**1702.4.2** The finished lines shall be free from ruggedness on sides and ends and be in true plane with the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

### 1702.5 Measurements for Payment

The painted markings shall be measured in linear metres with no deductions for intermediate gaps as shown on the drawings.

In respect of markings, like directional arrows and lettering, etc., the measurement shall be by numbers.

### 1702.6 Rate

The Contract unit rate for road markings shall be payment in full compensation for furnishing all labour, materials, tools, equipment, and carrying out the markings at site as per the approved drawing(s) or as directed by the Engineer and all other incidental costs necessary to complete the work in accordance with these Specifications.

## 1703 200 M/KILOMETRE STONES

### 1703.1 Scope

The work shall cover the supply, painting, lettering and fixing of distance measurement stones and shall include:

i) 200 metre stones
ii) Kilometre stones
iii) 5th kilometre stones

### 1703.2 Materials

The 200 m/kilometre stones may be made of local stones, concrete or any other material locally available and approved by the Engineer. The stones shall be bedded into the ground to a minimum grip of 600 mm with adequate plain cement concrete M10 grade foundations or as indicated in the drawings.

### 1703.3 Design

**1703.3.1** The dimensions of the stones, size, arrangement of letters and script shall be as per Plates 1 to 3 of IRC:8 and IRC:26. The background colour shall be white with black letters and numerals for names of stations and distances. The semi-circular portion of km and 5th km stones of rural roads shall have orange background with route numbers painted with black colour.

**1703.3.2** Kilometre stones shall be located on left side of the road as one proceeds from the station from which the kilometre count starts and shall be fixed at right angles to the line of the carriageway.

**1703.3.3** These shall be located on the edge of roadway beyond the shoulders, if necessary, on specially erected platforms. In cut sections, these shall be fixed clear of the shoulders and drains as shown in Plate 6 of IRC:8.

**1703.3.4** The inscription on Kilometre stones fixed shall be in Hindi in Devnagri script or the script of the recognized regional language at the discretion of the State Road Authority.

**1703.3.5** Numerals on Kilometre stones shall be inscribed in the international form of Indian numerals. Local or Devnagri numerals shall not be permitted to be used.

**1703.3.6** Letters and numerals on Kilometre stones shall be of the following size:

| | |
|---|---|
| Height of Letters for Place Name | 80 mm |
| Height of Numerals for Kilometerage | 130 mm |
| Height of Numerals for Route Numbers | 100 mm |

**1703.3.7** Spacing between adjacent letters/numerals shall be as given in IRC:8.

The other edge clearance shall be as given below:

| | |
|---|---|
| Top | 50 mm |
| Bottom | 75 mm |
| Sides | 50 mm |
| Spacing between Lines | 50 mm |

### 1703.4 Measurements for Payment

The measurement will be in numbers of 200 m, kilometre and 5th kilometre stones fixed at site.

### 1703.5 Rate

The Contract unit rate for 200 m/kilometre/5th kilometre stones shall be payment in full compensation for furnishing all labour, materials, tools, equipment and making the stones, painting and lettering and fixing at site and all other incidental costs necessary to complete the work in accordance with these Specifications.

## 1704 BOUNDARY STONES

### 1704.1 Scope

The work shall comprise of supplying and fixing boundary stones as per designs and Specifications given in IRC:25 and at locations indicated in the drawings or as directed by the Engineer.

### 1704.2 Measurements for Payment

The measurement shall be made in numbers of boundary stones fixed at site.

### 1704.3 Rate

The Contract unit rate for boundary stones shall be payment in full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying and fixing and all other incidental costs necessary to complete the work in accordance with these Specifications.

## 1705 FENCING

### 1705.1 Scope

The work shall comprise of fixing RCC M15 grade concrete posts and providing barbed wire fencing including necessary stays and entry gates as shown in the drawing(s) or as directed by the Engineer.

### 1705.2 Materials

The RCC posts shall be of size indicated in the drawings and embedded in concrete block to a depth not less than 600 mm below ground or as indicated in the drawings.

The barbed wire shall be of galvanized iron and shall conform to IS:278.

Entry gate(s) shall be made of tubular steel pipes conforming to IS:1239 or wooden plank as per the design shown in the drawing(s).

### 1705.3 Measurements for Payment

The measurement shall be in running metres of fencing and in square metres for the entry gates.

### 1705.4 Rate

The Contract unit rate for fencing including entry gates shall be payment in full compensation for furnishing all labour, materials, tools, equipment for fabrication and fixing at site and all other incidental costs necessary to complete the work in accordance with these Specifications.

## 1706 RAILINGS

### 1706.1 Scope

The work shall consist of supplying, fixing and erecting tubular steel or RCC railings as shown on the drawings or as directed by the Engineer.

### 1706.2 Materials

The railings shall be either of tubular steel conforming to IS:1239 or RCC in M20 grade conforming to Section 800 of these Specifications. The RCC railings shall be painted white with ordinary paint conforming to IS:164 or white washed with minimum three coats, or as directed by the Engineer.

**1706.3** The fabrication and painting of tubular steel railings except for the final coat shall be completed before dispatch to the site. Prior to the painting, all surfaces shall be grit blasted to the satisfaction of the Engineer and pickled. The priming coat of paint shall be applied as soon as the steel has dried and is still warm. The final three coats of paints shall be applied after erection of the railings.

### 1706.4 Measurements for Payment

The railings will be measured in linear metres from end to end along the face of the railings, including end and intermediate posts, with no deductions for gaps as shown on the drawings.

### 1706.5 Rate

The Contract unit rate for RCC or tubular steel railings shall be payment in full compensation for furnishing all labour, materials, tools, equipment and plants required for fabrication, connection, oiling, painting, white washing, temporary erection, inspection, test and final erection at site and all other incidental costs necessary to complete the work in accordance with these Specifications.

## 1707 REFLECTIVE PAVEMENT MARKERS (ROAD STUDS)

### 1707.1 Scope

The work shall cover the providing and fixing of Reflective Pavement Marker (RPM) or a road stud, a device which is bonded to or anchored within the road surface, for lane marking and delineation for night-time visibility as specified in the Contract.

### 1707.2 Material

**1707.2.1** Plastic body of RPM/road stud shall be moulded from ASA (Acrylic Styrene Acrylonitrite) or HIPS (Hi-impact Polystyrene) or Acrylonitrile Butadiene Styrene (ABS) or any other suitable material approved by the Engineer. The markers shall support a load of 13,635 kg tested in accordance with ASTM D 4280.

**1707.2.2** Reflective panels shall consist of number of lenses containing single or dual prismatic cubes capable of providing total internal reflection of the light entering the lens face. Lenses shall be moulded of methyl methecrylate conforming to ASTM D 788 or equivalent.

### 1707.3 Design

The slope or retro-reflecting surface shall preferably be 35˚ ± 5° to base and the area of each retro-reflecting surface shall be not less than 13.0 sqcm.

### 1707.4 Optical Performance

### 1707.4.1 *Unidirectional and bi-directional studs*

Each reflector or combination of reflectors on each face of the stud shall have a minimum Coefficient of Luminous Intensity (CIL) as given in **Tables 1700.6 or 1700.7** as appropriate.

**Table 1700.6 Minimum CIL Values for Category 'A' Studs**

| Entrance Angle | Observation Angle | CIL in mcd/lx | | |
|---|---|---|---|---|
| | | White | Amber | Red |
| 0˚U 5˚L&R | 0.3˚ | 220 | 110 | 44 |
| 0˚U 10˚L&R | 0.5˚ | 120 | 60 | 24 |

**Table 1700.7 Minimum CIL Values for Category 'B' Studs**

| Entrance Angle | Observation Angle | CIL in mcd/lx | | |
|---|---|---|---|---|
| | | White | Amber | Red |
| 0°U 6°L&R | 0.3° | 20 | 10 | 4 |
| 0°U 10°L&R | 0.5° | 15 | 7.5 | 3 |

***Notes :*** 1) The entrance angle of 0°U corresponds to the normal aspect of the reflectors when the reflecting road stud is installed in horizontal road surface.

2) The stud incorporating one or more corner cube reflectors shall be included in Category 'A'. The stud incorporating one or more bi-convex reflectors shall be included in Category 'B'.

**1707.4.2** *Omni-directional studs*

Each Omni-directional stud shall have a minimum (CIL) of 2 mcd/lx.

### 1707.5 Tests

**1707.5.1** Co-efficient of luminance intensity can be measured by procedure described in ASTM E 809 "Practice for Measuring Photometric Characteristics" or as recommended in BS:873-Part 4: 1973.

**1707.5.2** Under test conditions, a stud shall not be considered to fail the photometric requirements if the measured CIL at any one position of measurement is less than the values specified in **Tables 1700.6 or 1700.7** provided that

i) the value is not less than 80 percent of the specified minimum, and

ii) the average of the left and right measurements for the specific angle is greater than the specified minimum.

### 1707.6 Measurements for Payment

The road studs shall be measured in numbers.

### 1707.7 Rate

The Contract unit rate for studs shall be payment in full compensation for furnishing all labour, materials, tools required for installation and fixing at the site and incidentals to complete the work in accordance with these Specifications.

## Annexure-1700.1

(Refer Clause 1701.2.5)

Specifications for PMGSY Informatory Sign Board

A typical design of PMGSY Informatory Sign Board is shown in **Fig. 1700.1**. The specification and installation details of the typical sign board are given below:

i) The board will be a composite unit consisting of three Plates Aluminium Composite Materials (ACM), material specifications as per Clause 1701.3.The top most plate will be in diamond shape of 600 mm x 600 mm size, riveted with MS angle iron frame of 25 mm x 25 mm x 5 mm size on back on edges. The middle plate will be 1200 mm x 150 mm size riveted with MS angle iron frame of 25 mm x 25 mm x 5 mm size on back on edges. The main lower most MS plate will be 1500 mm x 600 mm size, riveted with MS angle iron frame of 25 mm x 25 mm x 5 mm size. Riveting of all the sheets over angle and flat iron frame will be done neatly to have plain surface on one side. The angle iron frame of the lower most plate and flat iron frame of the middle plate will be welded to two nos. 75 mm x 75 mm (12 SWG) sheet tubes posts placed at 1125 mm apart centre to centre. The top of the middle plate will be flushed with the top of 75 mm dia medium steel tube posts and these posts will be embedded in cement concrete M15 grade blocks of 450 mm x 450 mm x 600 mm below ground level. The height of bottom of the lower most plate will be 1200 mm from normal ground level and the bottom of middle plate will be 100 mm above the top level of the lower most plate. The diamond shaped plate mounted over flat angle iron frame will be connected to middle plate by square steel section of 47 mm x 47 mm, thickness 12 SWG having a spacing of 100 mm between the diamond shaped plate and middle plate and this square section will be riveted to the bottom point of the diamond shaped plate.

ii) PMGSY logo on back of all plates shall be painted with ready mixed synthetic enamel paints of superior quality in required shade and colour as specified. All the sections for frame and posts shall be painted with primer and two coats of Epoxy paint. The steel tube below ground level will be painted with three coats of Epoxy paint. The design, painting and lettering shall be done as per approved drawing.

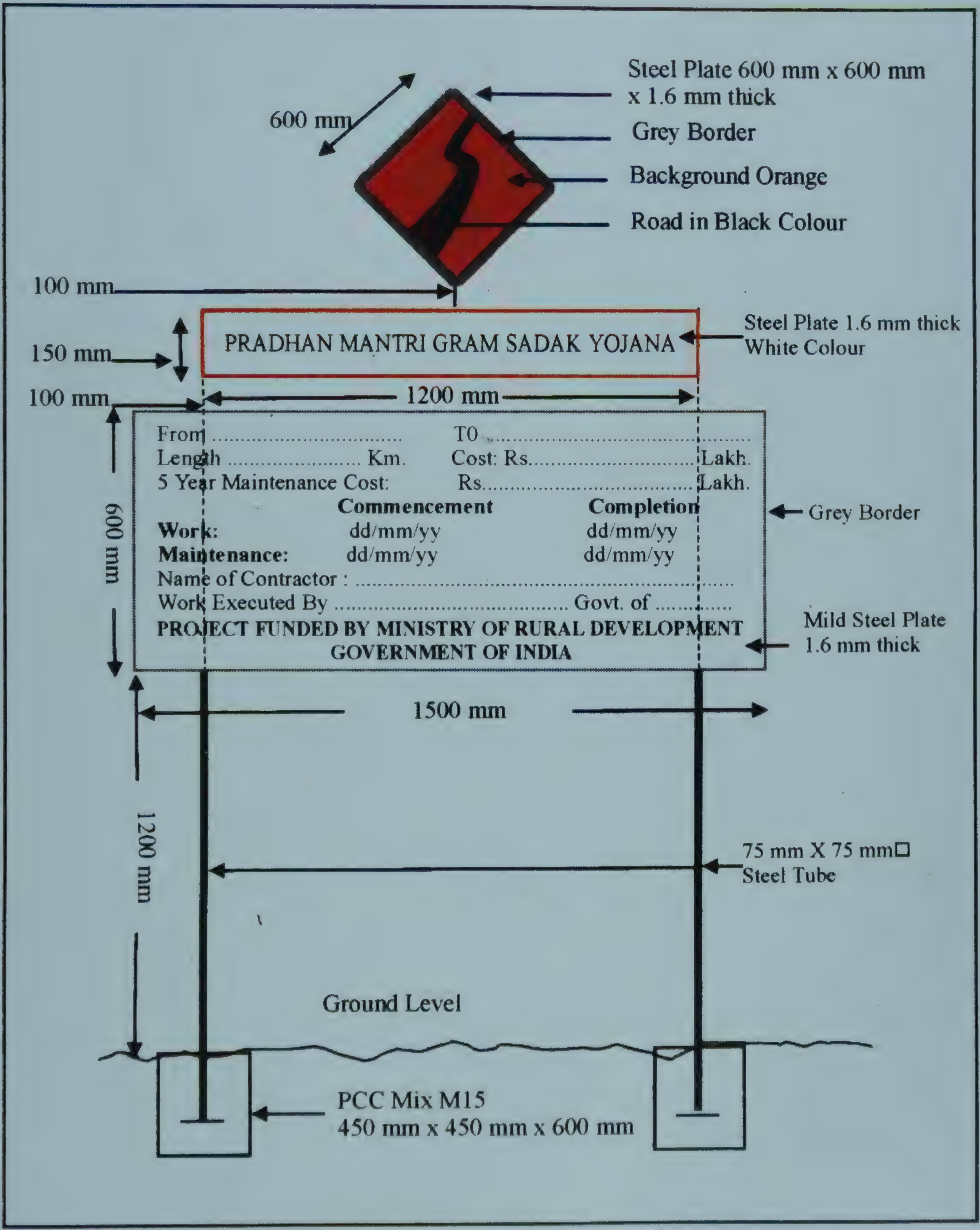

Steel Plate 600 mm x 600 mm x 1.6 mm thick
600 mm
Grey Border
Background Orange
Road in Black Colour
100 mm
PRADHAN MANTRI GRAM SADAK YOJANA
Steel Plate 1.6 mm thick White Colour
150 mm
100 mm
1200 mm
From ................................ T0 ..........................................
Length ...................... Km. Cost: Rs.................................Lakh.
5 Year Maintenance Cost: Rs...................................Lakh.
Commencement
Completion
Work: dd/mm/yy dd/mm/yy
Maintenance: dd/mm/yy dd/mm/yy
Name of Contractor : ...............................................................
Work Executed By ...................................... Govt. of ...........
PROJECT FUNDED BY MINISTRY OF RURAL DEVELOPMENT
GOVERNMENT OF INDIA
Grey Border
600 mm
Mild Steel Plate 1.6 mm thick
1500 mm
1200 mm
75 mm X 75 mm☐ Steel Tube
Ground Level
PCC Mix M15 450 mm x 450 mm x 600 mm

Fig. 1700.1 Typical pmgsy Logo & Informatory Sign Board

# 1800

# QUALITY CONTROL

## 1801 GENERAL

**1801.1** Appropriate quality control shall be exercised on all materials to be used, all procedures adopted and all works executed in conformance to the requirements of these Specifications. Quality control shall be exercised in accordance with the requirements laid down in the Quality Assurance Handbook for Rural Roads, issued by the NRRDA, May, 2007 and any amendments issued by the NRRDA. A three-tier system of quality control monitoring shall be adopted.

**1801.1.1** At the first tier, the District Programme Implementation Unit (DPIU) which is the executing agency, has the primary responsibility to ensure that all mandatory quality control tests are carried out and the test results are reliable. The Contractor shall set up a field laboratory at locations approved by the Engineer and equip the same with the needed equipment as per Section 100 of these Specifications.He shall provide adequately trained personnel to carry out all the required tests and quality control work as per Specifications and/or as directed by the Engineer. The Contractor shall carry out quality control tests on all materials and works to the stipulated frequency as detailed in Clause 1803. In the absence of clear indications about the method of testing and/or frequency of tests for any item, the instructions of the Engineer shall be followed.

**1801.1.2** At the second tier, periodic inspections of works shall be carried out by the State Quality Control Units/Monitors, set up/engaged by the State Government, independent of the Executing Agency/Programme Implementation Units. There shall be a State Quality Control Coordinator (SQC) of the rank of Superintending Engineer or above to coordinate and oversee the satisfactory functioning of the quality control mechanism within the state. The State Quality Monitors at the second tier of quality control shall inspect every work at least three times; the first two inspections shall be during the execution of the work and the third, on completion stage of the work (when the bituminous work is in progress) but not more than one month after completion. A monthly schedule for State Quality Monitors shall be drawn up by the State Quality Coordinator to ensure a systematic coverage.

**1801.1.3** At the third tier, the National Quality Monitors (NQM), engaged directly by the National Rural Roads Development Agency, shall carry out random inspection of works as per the instructions and guidelines prescribed by the NRRDA. The role of NQMs shall be where required and suggest improvements in the working of the Executing Agency.

**1801.2** All materials before incorporation in the work shall be tested by the Contractor for the tests indicated under 'Tests to be carried out Prior to Construction'. The tests shall be carried out from each source identified by the Contractor. The test samples shall be representative of the material available from the source. Any change/variation in the quality of material with depth of strata shall be reported. Important tests like Moisture-Density relationship (Proctor Compaction), Aggregate Impact Value, Plasticity Index, CBR and any other tests specified by the Engineer shall invariably be carried out in the presence of a representative of the Engineer. The test results shall form the basis for approval of the source and the material for incorporation in the work and shall be approved by the Engineer. For manufactured items, however, such as concrete pipes, elastomeric bearings etc., a test certificate obtained by the Manufacturer from an approved Test House shall be accepted.

**1801.3** During execution of the work, quality control for workmanship and ensuring conformance to specifications shall be exercised on the basis of the tests indicated under 'Quality Control Tests During Construction'. The tests shall be carried out by the Contractor independently or in the presence of Employer's representative, normally a Junior Engineer when available at site or where association of the Employer's representative in test is prescribed. The Junior Engineer shall record the results in his own handwriting. The Contractor shall be fully responsible for all the tests carried out for the work.

**1801.4** During the work on embankment, subgrade and pavement, the construction of subsequent layer shall be carried out after obtaining permission of the Engineer. Similar permission from the Engineer shall be obtained in respect of all other items of works prior to proceeding with the next stage of construction.

**1801.5** The Contractor shall carry out any modifications in the procedure of work, if found necessary during inspections at any of the three tiers of quality control as outlined in Clauses 1801.1.1, 1801.1.2 and 1801.1.3 or as directed by the Engineer. Works falling short of quality shall be rectified/redone by the Contractor at his own cost, and defective work shall also be removed from the site of works by the Contractor at his own cost.

**1801.6** The cost of field laboratory building including services, essential supplies like water, electricity, sanitary services and their maintenance and cost of all equipment, tools, materials, labour and incidentals to perform tests and other operations of quality control according to the Specification requirements shall be deemed to be incidental to the work and no extra payment shall be made for the same.

**1801.7** For testing of samples of soils/soil mixes, granular materials and mixes, bituminous materials and mixes, aggregates, cores, etc. samples in the required quantity and form shall be taken by the Contractor at his own cost.

**1801.8** For cement, bitumen, mild steel, and similar other materials where essential tests are to be carried out at the manufacturer's plant or at laboratories other than the field laboratory, the cost of samples, sampling, testing and furnishing of test certificates shall be borne by the Contractor. He shall also furnish the test certificates to the Engineer.

**1801.9** For testing of cement concrete at site during construction, arrangements for supply of samples, testing and supply of test results shall be made by the Contractor as per the frequency and number of tests specified in the Quality Assurance Handbook for Rural Roads issued by the NRRDA, May, 2007 and relevant IS Codes or relevant clauses of these Specifications, the cost of which shall be borne by the Contractor.

**1801.10** The method of sampling and testing of materials shall be as required by the Quality Assurance Handbook for Rural Roads, issued by the NRRDA, May, 2007. Where they are contradicting, the provision in these Specifications shall be followed. Where they are silent, sound engineering practice or directions of the Engineer shall be followed.

**1801.11** The materials for embankment construction shall be got approved from the Engineer. The responsibility for arranging and obtaining the land for borrowing or exploitation in any other way shall rest with the Contractor, who shall ensure smooth and uninterrupted supply of materials in the required quantity during the construction period.

Similarly, the supply of aggregates for construction of road pavement shall be from quarries approved by the Engineer. Responsibility for arranging uninterrupted supply of materials from the source shall be that of the Contractor.

**1801.12** All materials which the Engineer/his representative has determined as not conforming to the requirements of the contract shall be rejected whether in place or not; they shall be removed immediately from the site as directed. Materials, which have been subsequently corrected, shall not be used in the works unless approval is accorded in writing by the Engineer. Upon failure of the Contractor to comply with any order of the Engineer/his representative, given under this Clause, the Engineer/his representative shall have authority to cause the removal of rejected material and to deduct the cost of removal thereof from any payments due to the Contractor.

## 1802 CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITY

### 1802.1 General

All works performed shall conform to the lines, grades, cross-sections and dimensions shown on the drawings or as directed by the Engineer, subject to the permitted tolerances described hereinafter.

### 1802.2 Horizontal Alignment

Horizontal alignment shall be reckoned with respect to the centerline of the carriageway as shown on the drawings. The permitted tolerances for the edges of the carriageway and for the edges of the roadway and lower layers of pavement in plain and rolling terrain and in hilly terrain are given in **Table 1800.1**:

**Table 1800.1 Permitted Tolerances for Horizontal Alignment**

| | In Plain & Rolling Terrain | In Hilly Terrain |
|---|---|---|
| Edges of carriageway | ± 20 mm | ± 30 mm |
| Edges of roadway and lower layers of pavement | ± 30 mm | ± 50 mm |

### 1802.3 Surface Levels

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Engineer beyond the tolerances mentioned in **Table 1800.2**.

### Table 1800.2 Permitted Tolerances in Surface Levels

| | | | | |
|---|---|---|---|---|
| 1) | Subgrade | | + 20 mm | – 25 mm |
| 2) | Sub-base | | + 10 mm | – 20 mm |
| 3) | Base-course | | | |
| | a) | Gravel/Soil Aggregate, Cement treated soil, wet mix macadam, shoulder construction and machine laid crusher run macadam | + 10 mm | – 10 mm |
| | b) | Manually laid crusher run macadam | + 15 mm | – 15 mm |
| | c) | Waterbound macadam | + 15 mm | – 15 mm |
| | d) | Stone set pavement | + 15 mm | – 15 mm |
| | e) | Bituminous macadam | + 6 mm | – 6 mm |
| 4) | | Surface Course | | |
| | a) | Surface dressing, premix carpet and mix seal surfacing | | |
| | | - machine laid | + 6 mm | – 6 mm |
| | | - manually laid | + 10 mm | – 10 mm |
| | b) | Semi Dense Bituminous concrete | + 6 mm | – 6 mm |
| | c) | Cement concrete pavement<br>(upto – 8 mm at 0-300 mm from the edges) | + 5 mm | – 5 mm |

Provided, however, that the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course, if the thickness of the former is thereby reduced by more than 6 mm for flexible pavements and 5 mm for concrete pavements.

For checking compliance with the above requirement for subgrade, sub-base and base courses, measurements of the surface levels shall be taken on a grid of points placed at 10 m longitudinally and 2.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversely, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the permitted tolerance.

For checking the compliance with the above requirement for bituminous wearing courses and concrete pavements, measurements of the surface levels shall be taken on a grid of points spaced at 6.25 m along the length and at 0.5 m from the edges and at the centre of the pavement. In any length of pavement, compliance shall be deemed to be met for the final road surface, only if the tolerance given above is satisfied for any point on the surface.

### 1802.4 Surface Regularity of Pavement Courses

The maximum allowable difference between the road surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centreline of the road at points decided by the Engineer shall be as indicated in **Table 1800.3**.

**Table 1800.3 Maximum Permissible Undulation**

| **Type of Construction** | | | **Maximum Permissible Undulation (Measured with 3 m Straight Edge)** | |
|---|---|---|---|---|
| | | | **Longitudinal Profile** | **Cross Profile** |
| 1) | Sub-grade | | 20 mm | 15 mm |
| 2) | Sub-base course | | 12 mm | 10 mm |
| 3) | Base course | | | |
| | a) | Gravel/soil aggregate, cement stabilized | 12 mm | 10 mm |
| | b) | WBM Grade 1 | 15 mm | 12 mm |
| | c) | WBM Grade 2/Grade 3 and crusher run macadam | 12 mm | 8 mm |
| | d) | Wet mix macadam | 10 mm | 8 mm |
| | e) | Bituminous macadam | 12 mm | 8 mm |
| 4) | | Surface Course | | |
| | a) | Stone set pavement | 12 mm | 10 mm |
| | b) | Surface dressing | 10 mm | 12 mm |
| | c) | Premix carpet, mix seal surfacing | 8 mm | 8 mm |
| | d) | Semi Dense Bituminous Concrete | 6 mm | 4 mm |
| | e) | Cement concrete pavement | 6 mm | 6 mm |

### 1802.5 Rectification

Where the surface regularity of subgrade and the various pavement courses fall outside the specified tolerances, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

i) **Subgrade :** Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by scarifying the lower layer and adding fresh material and recompacting to the required density. The degree of compaction and the type of material to be used shall conform to the requirements of Section 300.

ii) **Granular Sub-base :** Same as at (i) above, except that the degree of compaction and the type of material to be used shall conform to the requirements of Section 400.

iii) **Lime/Cement Stabilized Soil Sub-base :** For lime/cement treated materials where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described hereinbelow.

For cement treated material, when the time elapsed between detection of irregularity and the time of mixing of the material is less than 2 hours, the surface shall be scarified to a depth of 50 mm supplemented with freshly mixed materials as necessary and recompacted to the relevant specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to Specification. This shall also apply to lime treated material except that the time criterion shall be 3 hours instead of 2 hours.

iv) **Water Bound Macadam/Wet Mix Macadam Sub-base/Base :** Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted as per requirements of Section 400.

v) **Bituminous Constructions :** For bituminous construction other than wearing course, where the surface is low, the deficiency shall be corrected by adding fresh material over a suitable tack coat if needed and recompacting to specifications. Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications.

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications. In all cases where the removal and replacement of a bituminous layer is involved, the area treated shall be not less than 5 m in length and not less than 3.5 m in width.

vi) **Dry Lean Concrete Sub-base/Roller Compacted Cement Concrete :** The defective length of the course shall be removed to full depth and replaced with material conforming to Section 1500, as applicable. The area treated shall be at least 3 m long, not less than 1 lane wide and extend to the full depth. Before relaying the course, the disturbed subgrade or layer below shall be corrected by levelling, watering and compaction.

vii) **Cement Concrete Pavement :** The defective areas having surface irregularity exceeding the specified limits may be rectified by bump cutting or scabbling or grinding using approved equipment. When required by the Engineer, areas which have been reduced in level by the above operation(s) shall be retextured in an approved manner either by cutting grooves (5 mm deep) or roughening the surface by hacking the surface. If high areas in excess of 6 mm or low areas in excess of 3 mm occur, exceeding the permitted numbers and if the Contractor cannot rectify, the slab shall be demolished and reconstructed by the Contractor at his own expense and in no case the area removed shall be less than the full width of the lane in which the irregularity occurs and full length of the slab.

If deemed necessary by the Engineer, any section of the slab which deviates from the specified levels and tolerances, shall be demolished and reconstructed by the Contractor at his own expense.

## 1803 QUALITY CONTROL TESTS

### 1803.1 General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in relevant Sections of these Specifications.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to require the Contractor to carry out additional tests as frequently as he may deem necessary, to ensure that the materials and works comply with the appropriate specifications. However, the number of tests recommended in **Tables 1800.4 to 1800.55** may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of materials can still be maintained.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per sound engineering practice or as per directions of the Engineer.

### 1803.2 Tests on Earthwork

#### 1803.2.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction and their frequency shall be as given in **Table 1800.4**.

**Table 1800.4 Quality Control Tests Prior to Construction**

| **Type of Test** | | | **Frequency** |
|---|---|---|---|
| **A.** | | **Earthwork for Embankment** | |
| | 1) | Soil Classification as per IS:1498<br>i) Sieve Analysis (Wet Sieve Analysis except for cohesionless soils)<br>ii) LL, PL and PI | One test from each source for one km length, or part thereof. |
| | 2) | Standard Proctor Compaction Test (IS:2720 Part 7). Test results to ascertain Dry Density-Moisture Content Relationship. | -do- |
| | 3) | Free Swell Index Test (IS:2720 Part 40)(a). | -do- |
| | 4) | Deleterious Content(b) | |
| | | i) Organic matter content by loss-on-Ignition method or as per IS:2720-Part 22. | -do- |
| | | ii) Total soluble sulphate content (IS:2720-Part 27) where suspected on past experience. This can be easily confirmed by a quick test using Barium Chloride. | -do- |
| **B.** | | **Earthwork for Subgrade (Cutting or Filling)** | |
| | | i) Tests at 1 to 4, under A above. (In case the soil for embankment meets the prescribed requirements for the Subgrade, the above four tests need not be repeated.) | One test for each km length or part thereof, from each source.(c) |
| | | ii) CBR Test (IS:2720 Part 16) soaked/unsoaked as specified. | One test for each km: this will comprise testing of 3 specimens and the CBR value will be reported as average of the three test values. |

***Notes:***

a) Test for free swell index to be conducted only in case of expansive soils.

b) Presence of deleterious content can be initially detected through colour, odour and existence of any organic matter. Where such observations justify need for further testing, simple tests at (i) and (ii) above shall be carried out. Detailed testing as per IS:2720-Part 22 and Part 27 shall be done only after presence of deleterious content is confirmed by simple tests.

c) For hill roads, the frequency of tests may be increased depending upon the variability of the strata met.

**1803.2.2** *Tests during construction*

The quality control tests to be carried out during construction and their frequency shall be as given in **Table 1800.5**.

**Table 1800.5 Quality Control Tests during Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Placement Moisture (IS:2720 Part 2) Where facility for oven drying is not available, any of the following quick test methods can be used:<br>i) Sand bath method<br>ii) Rapid moisture meter | At least 3 tests daily (well spread over the day's work) |
| 2) | Insitu Density Measurements (IS:2720 Part 28) (Each layer) | -do-<br>i) Average of 3 tests results shall not be less than the specified degree of compaction.<br>ii) Individual test values of the degree of compaction obtained shall not be less than 1 percent of the specified value of degree of compaction.<br>(For example, for the specified 100 percent Proctor density, the individual test value shall not be less than 99 percent of Proctor density and the average of the three (or more) tests carried out in a day shall not be less than 100 percent Proctor density). |
| 3) | Thickness of subgrate layer | At random |

### 1803.3 Tests on Granular Sub-Base

### 1803.3.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction and their frequency shall be as given in **Table 1800.6**.

**Table 1800.6 Quality Control Tests Prior to Construction**

| | Type of Test | Frequency |
|---|---|---|
| 1) | Soil Classification as per IS:1498.<br>i) Wet Sieve Analysis, except for cohesionless soils<br>ii) Liquid and Plastic Limits | Average of three tests from each source. |
| 2) | Combined Grading and Plasticity tests on materials from different sources, mixed in the design proportions. This shall be done when materials from more than one source are combined. | One test on the combined material for 500 m length of road or part thereof. |
| 3) | Proctor Compaction Test (IS:2720 Part 7) | One test on the material from each source or on the combined material, as the case may be. |
| 4) | Wet Aggregate Impact Value Test (IS:5640) where soft/marginal aggregates are used e.g, Laterite, Kankar, Brick Ballast etc. | One test from each source identified by the Contractor. |
| 5) | CBR test (IS:2720 Part 16) on representative sample compacted at 100 percent Proctor dry density. | One test per km length (average of a set of three specimens). |

***Note:*** Where materials from more than one source are to be combined in the desired proportions, the tests at Sl. Nos. 2, 3 and 5 should be carried out on the combined material. For new sources, test frequencies shall be at least three tests for each source (average of three tests). The samples shall be taken at representative locations and at mean depth of proposed excavation.

### **1803.3.2** *Tests during construction*

The field quality control tests during construction shall be as given in **Table 1800.7**.

Table 1800.7 Quality Control Tests during Construction

| Type of Test | | Frequency |
|---|---|---|
| 1) | Wet Sieve Analysis (IS:2720 Part 4) on the GSB material combined in the design proportions from various sources. | At least one test to be carried out daily. |
| 2) | Liquid and Plastic Limit tests (IS:2720 Part 5). | -do- |
| 3) | Placement Moisture Content (IS:2720 Part 2) | At least 3 tests to be carried out daily, well spread over the day's work. |
| 4) | Insitu Density measurements (IS:2720 Part 28). | -do- |
| 5) | Thickness of compacted layer | At random |

## 1803.4 Tests on Lime-Treated Soil Sub-Grade or Sub-Base

### 1803.4.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.8**.

Table 1800.8 Quality Control Tests Prior to Construction

| Type of Test | | Frequency |
|---|---|---|
| 1) | Purity of Lime (IS:1514) | One test for each lot of lime |
| 2) | Determination of optimum quantity of lime to attain the specified reduction in PI and/ or to achieve the specified CBR | Mean of two tests. |
| 3) | Plasticity Index test (IS:2720 Part 5) of the lime-treated soil (mixed with the required amount of lime) | Mean of two tests per km length on the representative sample of a lime-treated soil mix with the required amount of lime. |
| 4) | CBR (IS:2720 Part 16) or Unconfined Compressive Strength (IS:4332 Part 5) if specified. | One test on a set of 3 specimens per km length. |

### 1803.4.2 *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.9**.

**Table 1800.9 Quality Control Tests during Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Pulverization of soil clods | At least 3 tests daily, well spread over the day's work. |
| 2) | Placement Moisture Content (IS:2720 Part 2) | -do- |
| 3) | Insitu Density measurements (IS:2720 Part 28) | -do-<br>i) Average of 3 test results shall not be less than the specified degree of compaction.<br>ii) Individual test values of the degree of compaction attained shall not be less than 1 percent of the specified degree of compaction. |
| 4) | Thickness of compacted layer | At random |

### 1803.5 Tests on Cement Treated Soil Sub-Base/Base

#### 1803.5.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.10**.

**Table 1800.10 Quality Control Tests Prior to Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Quality of cement and Purity of Lime (IS:1514) (if used for pre-treatment) | One test for each lot |
| 2) | Unconfined Compressive Strength Test (IS:4332 Part 5) | One test on a set of 3 specimens per km length. |

#### 1803.5.2 *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.11**.

Table 1800.11 Quality Control Tests during Construction

| Type of Test | | Frequency |
|---|---|---|
| 1) | Pulverization of soil clods | At least 3 tests daily, well spread over the day's work. |
| 2) | Placement Moisture Content (IS:2720 Part 2) | -do- |
| 3) | Insitu Density measurements (IS:2720 Part 28) | -do-<br>i) Average of 3 test results shall not be less than the specified degree of compaction.<br>ii) Individual test values of the degree of compaction attained shall not be less than 1 percent of the specified degree of compaction. |
| 4) | Thickness of compacted layer | At random |

### 1803.6 Tests on Water Bound Macadam Sub-Base/Base/Surfacing

### 1803.6.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.12**.

Table 1800.12 Quality Control Tests Prior to Construction

| Type of Test | | Frequency |
|---|---|---|
| 1) | Aggregate Impact Value Test (IS:2386 Part 4) | One test from each identified source. |
| 2) | Aggregate Water Absorption Test (IS:2386 Part 3) | -do- |
| 3) | Soundness Test of Aggregates (where water absorption, as at 2 above, exceeds 2%) (IS:2386 Part 5). | -do- |
| 4) | Grading, LL and PI of Crushable Screenings (IS:2720 Part 5) (where Screenings are to be used from the same source as the Stone Aggregates, this test is not needed). | -do- |
| 5) | LL and PI of the Binding Material, when used. | -do- |

### 1803.6.2 *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.13**.

Table 1800.13 Quality Control Tests during Construction

| | Type of Test | Frequency |
|---|---|---|
| 1) | Grading of Stone Aggregates and Screenings (IS:2386 Part 1) | At least 2 tests to be carried out for a days work. |
| 2) | Flakiness Index of Stone Aggregates (IS:2386 Part 1) | - do - |
| 3) | PI of Crushable Screenings/binding material (IS:2720 Part 5) | - do - |
| 4) | Aggregate Impact Value (IS:2386 Part 4) | At random one test per km |
| 5) | Thickness of compacted layer | At random |

## 1803.7 Tests on Wet Mix Macadam and Crusher Run Macadam Base

### 1803.7.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.14**.

Table 1800.14 Quality Control Tests Prior to Construction

| | Type of Test | Frequency |
|---|---|---|
| 1) | Aggregate Impact Value Test (IS:2386 Part 4) | One to two tests on representative sample from each source identified by the Contractor, depending on variability. |
| 2) | Flakiness Index Test (IS:2386 Part 1) | -do- |
| 3) | Water Absorption Test (IS:2386 Part 3) | -do- |
| 4) | Soundness Test, if the water absorption exceeds 2 percent | -do- |
| 5) | Grading Test (IS:2386 Part 1) | -do- |
| 6) | Atterberg Limits of portion of aggregate passing 425 micron sieve (IS:2720 Part 5) | -do- |
| 7) | Proctor Compaction Test (IS:2720 Part 7) (after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size) alongwith Dry Density-Moisture Content Relationship | -do- |

### 1803.7.2 *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.15**.

**Table 1800.15 Quality Control Tests during Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Grading Test (IS:2386 Part 1) | At least one test per day. |
| 2) | Aggregate impact value (IS:2386-Part 4) | At random one test per km. |
| 3) | Placement Moisture Content (IS:2720 Part 2) | At least three tests per day. |
| 4) | Density of Compacted Layer (IS:2720 Part 28) | -do- |
| 5) | Thickness of compacted layer | At random |

### 1803.8 Tests on Stone-set Pavement

The tests relating to granular sub-base and WBM base shall be as given in Clauses 1803.3 and 1803.6 respectively. For stone-sets, the following tests shall be carried out.

#### 1803.8.1 *Tests prior to construction*

The tests/checks to be carried out prior to construction shall be as given in **Table 1800.16**.

**Table 1800.16 Quality Control Tests/Checks Prior to Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Shape and dimension | Three samples on receipt at site |
| 2) | Water absorption (IS:2386 Part 3) | Three samples on receipt at site |

#### 1803.8.2 *Tests during construction*

The tests during construction shall be as given in **Table 1800.17**.

**Table 1800.17 Quality Control Tests during Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Aggregate Impact Value (IS:2386 Part 4) | At random one test per 500 m length |
| 2) | Polished Stone Value (BS: 812 Part 114) | At random one test per 500 m length |
| 3) | Dressing of stone (hammer dressed on top) | At random one test per 200 m length |

### 1803.9 Tests on Prime Coat and Tack Coat

#### 1803.9.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.18**. These tests shall be carried out on the bitumen binders (Emulsion/Cutback) brought on the site by the Contractor for use in the work. Where paving bitumen is used for the tack coat, the tests on bitumen shall be as specified in **Table 1800.20**.

**Table 1800.18 Quality Control Tests Prior to Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Viscosity (using Saybolt Furol Viscometer) (IS:8887) | One test for each lot |
| 2) | Residue on 600 micron sieve (IS:8887) | -do- |
| 3) | Storage Stability Test (IS:8887) | -do- |
| 4) | Flash Point Test, where bituminous cutback is to be used (IS:217) | -do- |
| 5) | Viscosity Test (IS:217), where bituminous cutback is to be used | -do- |

### 1803.9.2 *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.19**.

**Table 1800.19 Quality Control Tests during Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Temperature of Binder, when emulsion/cutback is to be used | Regularly |
| 2) | Rate of Spread of Binder | At least two tests per day. |
| 3) | Curing of Primer/Tack surface | Before any subsequent treatment. |

## 1803.10 Tests on Bituminous Macadam

### 1803.10.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.20**.

**Table 1800.20 Quality Control Tests Prior to Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Quality of Binder (Paving Bitumen as per IS:73) | |
| | a) Absolute Viscosity and Penetration Test | One test per lot |
| | b) R&B Softening Point Test | -do- |
| | c) Ductility Test | -do- |
| 2) | Quality of Binder (Modified Bitumen) (IS:15462 and IRC:SP:53*) | |
| | a) Penetration Test | -do- |
| | b) R&B Softening Point Test | -do- |

| | | |
|---|---|---|
| | c) Elastic Recovery Test | -do- |
| | d) Separation Test | -do- |
| 3) | Aggregate Impact Value Test (IS:2386 Part 4) | One test on representative sample per km length from each source identified by the Contractor |
| 4) | Flakiness Index Test (IS:2386 Part 1) | Two tests per source |
| 5) | Bituminous Stripping of Aggregate Test (IS:6241) | One test per source |
| 6) | Water Absorption (IS:2386 Part 3) | -do- |
| 7) | Soundness Test, if water absorption of aggregate exceeds 2 percent (IS:2386 Part 5) | -do- |

* Refer to para 12 of IRC:SP:53

**1803.10.2** *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.21**.

**Table 1800.21 Quality Control Tests during Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Grading of Aggregate (IS:2386 Part 1) | At least one test per day. |
| 2) | Binder Content | At least two tests per day. |
| 3) | Density of Compacted Layer | At least one test per day. |
| 4) | Temperature of Binder before mixing | Regularly |
| 5) | *Temperature of mix during laying and compaction | Regularly |
| 6) | Thickness of compacted layer | Regular, at close intervals |
| 7) | Aggregate Impact Value (IS:2386 Part 4) | At random one test per km |

* Temperature measurement will be done by using metallic contact thermometer with digital display

## 1803.11 Tests on Semi Dense Bituminous Concrete

**1803.11.1** *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.22**.

Table 1800.22 **Quality Control Tests Prior to Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Quality of Binder (Paving Bitumen as per IS:73) | |
| | a) Absolute Viscosity and Penetration Test | One test per lot |
| | b) R&B Softening Point Test | -do- |
| | c) Ductility Test | -do- |
| 2) | Quality of Binder (Modified Bitumen) (IS:15462 and IRC:SP:53*) | |
| | a) Penetration Test | -do- |
| | b) R&B Softening Point Test | -do- |
| | c) Elastic Recovery Test | -do- |
| | d) Separation Test | -do- |
| 3) | Aggregate Impact Value Test (IS:2386 Part 4) | One test on representative sample per km length from each source identified by the Contractor |
| 4) | Flakiness Index Test (IS:2386 Part 1) | Three tests per source |
| 5) | Bitumen Stripping of Aggregate Test (IS:6241) | One test per source |
| 6) | Water Absorption (IS:2386 Part 3) | -do- |
| 7) | Soundness Test, (Sodium or Magnesium sulphate test) (IS:2386 Part 3) | -do- |
| 8) | Sand equivalent test | -do- |

* Refer to para 12 of IRC:SP:53

**1803.11.2** *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.23**.

**Table 1800.23 Quality Control Tests During Construction**

| | Type of Test | Frequency |
|---|---|---|
| 1) | Mix Grading (IS:2386 Part 1) | Individual constituent and mixed aggregate from dryer. At least two tests per day. |
| 2) | Stability and voids analysis of mix | At least two tests per day |
| 3) | Binder Content | At least two tests per day |
| 4) | Temperature of Binder in boiler, and aggregate in dryer | At regular intervals. |
| 5) | **Temperature of mix during laying and compaction | At regular intervals |
| 6) | Rate of spread of mix and thickness of compacted layer | Regular, at close intervals |
| 7) | Density of compacted layer | One test per 700 sqm area Minimum 3 tests per day |
| 8) | Aggregate Impact Value (IS:2386 Part 4) | At random one test per km |

** Temperature measurement will be done by using metallic contact thermometer with digital display

### 1803.11.3 *Acceptance criteria*

The Acceptance criteria for test on density (N=3 minimum) and Marshall stability (N=2 minimum) shall be subject to the condition that the mean value of N samples is not less than the specified value plus [1.65 – 1.65/(No. of samples)$^{0.5}$] x standard deviation. **Table 500.17** shall govern the permissible variation in the mix and temperature.

## 1803.12 Tests on Surface Dressing and Mix Seal Surfacing with Seal Coat Type A

### 1803.12.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.24**.

### Table 1800.24 Quality Control Tests Prior to Construction

| Type of Test | | Frequency |
|---|---|---|
| 1) | Quality of Binder (Paving Bitumen as per IS:73) | |
| | a) Absolute Viscosity and Penetration Test | One Set of tests per lot (Average of three tests) |
| | b) R&B Softening Point Test | -do- |
| | c) Ductility Test | -do- |
| 2) | Quality of Binder (Bitumen Emulsion) | |
| | a) Viscosity (IS:8887) | -do- |
| | b) Residue on 600 micron sieve (IS:8887) | -do- |
| | c) Storage Stability Test (IS:8887) | -do-- |
| 3) | Quality of Binder (Modified Bitumen) (IS:15462 and IRC:SP:53*) | |
| | a) Penetration Test | -do- |
| | b) R&B Softening Point Test | -do- |
| | c) Elastic Recovery Test | -do- |
| | d) Separation Test | -do- |
| 4) | Aggregate Impact Value Test (IS:2386 Part 4) | One test per km length on representative sample from each source identified by the Contractor |
| 5) | Flakiness Index Test (IS:2386 Part 1) | -do- |
| 6) | Bitumen Stripping of Aggregate Test (IS:6241) | -do- |
| 7) | Water Absorption (IS:2386 Part 3) | -do- |

* Refer to para 12 of IRC:SP:53

**1803.12.2** *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.25**.

**Table 1800.25 Quality Control Tests during Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Rate of spread of binder | At least two tests per day |
| 2) | Rate of Spread of aggregate | -do- |
| 3) | Grading of Aggregate (IS:2386 Part 1) | At least one test per day |
| 4) | Temperature of binder during spraying (Annex-I) | Regularly, at close intervals. |
| 5) | Storage stability Test for Bitumen Emulsion | One test per day |
| 6) | Aggregate Impact Value (IS:2386 Part 4) | At random one test per km |

## 1803.13 Tests on Premix Carpet and Mix Seal Surfacing with Seal Coat Type B and Type C

### 1803.13.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.26**.

**Table 1800.26 Quality Control Tests Prior to Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Quality of Binder (Paving Bitumen as per IS:73) | |
| | a) Absolute Viscosity and Penetration Test | One set of tests per lot |
| | b) R&B Softening Point Test (IS:73) | -do- |
| | c) Ductility Test (IS:73) | -do- |
| 2) | Quality of Binder (Bitumen Emulsion) | |
| | a) Viscosity (IS:8887) | -do- |
| | b) Residue on 600 micron sieve (IS:8887) | -do- |
| | c) Storage Stability Test (IS:8887) | -do- |
| 3) | Quality of Binder (Modified Bitumen) (IS:15462 and IRC:SP:53*) | |
| | a) Penetration Test | -do- |
| | b) Softening Point Test | -do- |
| | c) Elastic Recovery Test | -do- |
| | d) Separation Test | -do- |

| | | |
|---|---|---|
| 4) | Aggregate Impact Value Test (IS:2386 Part 4) | One test per km length on representative sample from each source identified by the Contractor |
| 5) | Flakiness Index Test (IS:2386 Part 1) | -do- |
| 6) | Bitumen Stripping of Aggregate Test (IS:6241) | -do- |
| 7) | Water Absorption (IS:2386 Part 3) | -do- |

* Refer to para 12 of IRC:SP:53

### 1803.13.2 *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.27**.

**Table 1800.27 Quality Control Tests during Construction**

| Type of Test | | Frequency |
|---|---|---|
| 1) | Grading of Aggregates (IS:2386 Part 1) | At least two tests per day |
| 2) | Binder Content before seal coat | At least two tests per day |
| 3) | Temperature of Binder | Regular close intervals |
| 4) | Thickness before and after compaction | Regularly at close intervals |
| 5) | Aggregate Impact Value (IS:2386 Part 4) | At random one test per km |

## 1803.14 Tests on Modified Binders

The essential quality control tests and their frequencies shall be as given in **Table 1800.28**.

**Table 1800.28 Essential Tests and their Frequency**

| Test | Test Method | Frequency |
|---|---|---|
| Quality of Binder | Penetration IS:1203<br>Softening Point IS:1205<br>Elastic Recovery IS:15462-2004<br>Separation IS:15462-2004 | One Test per lot of 10 tonnes for each source. |

## 1803.15 Tests on Brickwork for Structures

### 1803.15.1 *Tests prior to construction*

The tests/checks to be carried out prior to construction shall be as given in **Table 1800.29**.

Table 1800.29 Quality Control Tests Prior to Construction

| S. No. | Material | Test/Check | Frequency |
|---|---|---|---|
| 1) | Bricks | a) Colour and Dimensional check | 3 samples at random at source |
| | | b) Water absorption (IS:3495 Part 2) | 3 samples at source or after procurement |
| | | c) Efflorescence (IS:3495 Part 3) | In case of doubt, at source |
| | | d) Compressive strength (IS:3495 Part 1) | 3 samples at random, at source |
| 2) | Cement | a) Setting time of cement (IS:4031 part 5) | 3 samples of same type and grade of cement. |
| 3) | Lime | Purity (IS:1514) | One test for each lot |
| 4) | Sand (Natural and crushed stone) | Gradation (IS:2115) | 3 samples for each source of supply |
| | | Deleterious material and organic impurities (IS:2386 Part 2) | If in doubt one test |
| 5) | Water | Normally potable water is good enough. If impurities are present test as per IS:3025 (parts 17, 24, 32) | Samples taken at each source tested at an approved test house |

### 1803.15.2 *Tests during construction*

The tests to be carried out during construction shall be as given in **Table 1800.30**.

Table 1800.30 Quality Control Tests during Construction

| S. No. | Material/Work | Test/Check | Frequency |
|---|---|---|---|
| 1) | Bond and Plumbness | English bond, verticality by Plumb bob | For each course |
| 2) | Laying in Mortar | Laying in full bed of mortar with proper lapping | - do - |
| 3) | Individual Course | Height of course and Joint thickness (IS:2212) | - do - |
| 4) | Top of coping (If provided) | Sloping to drain off water | Daily |

| | | | |
|---|---|---|---|
| 5) | Mortar for Joints | Mix proportions (Control on quantity of cement/lime by weight) | Each batch |
| | | Consistency and water retentivity (IS:2250) | As required at close interval |
| | | Compressive Strength (IS:2250) | 3 samples of cubes where specified |
| 6) | Arches (Additional Tests) | a) Dimensions of abutment-pier for multiple arches (IS:2118) | Regularly |
| | | b) Centering for arch | For each span |
| | | c) Compaction and thickness of filling material over crown and haunches | Regularly |
| | | d) Thickness of Joints | Regularly |

### 1803.16 Tests on Stone Masonry for Structures

### 1803.16.1 *Tests prior to construction*

The tests/checks to be carried out prior to construction shall be as given in **Table 1800.31**.

**Table 1800.31 Quality Control Tests Prior to Construction**

| S. No. | Material | Test | Frequency |
|---|---|---|---|
| 1) | Stones | a) Shape and Dimension (IS:1597 Part 1) | 3 samples on receipt at site |
| | | b) Water absorption (IS:1124) | 3 samples on receipt at site |
| | | c) Dressing of Stones via Hearting, Bond, Quoin, Face stones, Headers, etc. (IS:1129) | Once for each stock after selection for individual work |
| 2) | Cement | Setting time of cement (IS:4031 Part 5) | 3 samples of same type and grade of cement |
| 3) | Lime (If used) | Purity (IS:1514) | One test for each lot |
| 4) | Sand | Gradation (IS:2116) | a) 3 samples for each source of supply |
| | | Deleterious materials and organic impurities (IS:2386 Part 2) | b) If in doubt, one test |

| | | | |
|---|---|---|---|
| 5) | Water | If impurities are present, test as per IS:3025 (Parts 17,24, 32) | Samples taken at each source, tests at an approved test house |
| 6) | Precast concrete bond blocks | a) Size | 3 samples for each size on receipt at site |
| | When natural stone of appropriate size not available | b) Cube strength of mix used | 3 samples |
| 7) | Mortar for Joints | Consistency and water retentivity (IS:2250)<br>Mix proportions for different works<br>Compressive Strength (IS:2250) | As required<br>Daily<br>3 samples of cubes where specified |

**1803.16.2** *Tests/checks during construction*

The tests/checks to be carried out prior to construction shall be as given in **Table 1800.32**.

**Table 1800.32 Quality Control Tests during Construction**

| S. No. | Material/Work | Test/Check | Frequency/Stage |
|---|---|---|---|
| 1) | Bond and Plumbness | For stability and appearance with plumb bob | While laying each course |
| 2) | Laying in mortar | Horizontality of courses, verticality and staggering of joints | - do - |
| 3) | Individual course | Height Joint Thickness and laying (IS:1597 Part 1 & 2 and IS:2212 ) | - do - |
| 4) | Arches<br>(Additional checks) | a) Centering and simultaneous commencement of work from both ends (IS:2118) | Check during erection |
| | | b) Compaction and thickness of filling material over crown and haunches | As and when work is on hand |
| | | c) Erection of abutment pier for multiple arches | As and when such work is on hand |
| | | d) Thickness of Joints | Check during construction |
| 5) | Top of coping (If provided) | Sloping to drain off water | Once on either side of parapet |

## 1803.17 Tests/Checks on Concrete for Structures

### 1803.17.1 *Tests prior to construction*

The tests and checks to be carried out prior to construction shall be as given in **Table 1800.33**.

**Table 1800.33 Quality Control Tests Prior to Construction**

| S. No. | Material | Test/Check | Frequency |
|---|---|---|---|
| 1) | Cement | a) Setting Time (IS:4031 Part 5) | One test for 10 tonnes of cement (same brand & grade) |
| | | b) Soundness (IS:4031 Part 3) | - do - |
| | | c) Compressive strength of mortar cube (IS:4031 Part 6) (Table 800.3) | 3 specimens for each lot |
| 2) | Coarse Aggregates | a) Gradation for PCC or RCC works | 3 samples for each quarry source |
| | | b) Flakiness index (IS:2386 Part 1) | - do - |
| | | c) Deleterious constituents (IS:2386 Part 2) | If in doubt, one test |
| | | d) Water absorption/content (IS:2386 Part 3) | Once for each source of supply |
| | | e) Aggregate Impact value (IS:2386 Part 4) | One test per source of supply |
| | | f) Soundness (IS:2386 Part 5) [if water absorption exceeds 2 percent] | - do - |
| | | g) Alkali Silica reactivity (IS:2386 Part 7) | If in doubt, one test at approved test house |
| 3) | Fine Aggregates | a) Gradation (IS:2386 Part 1) | 3 samples for each source of supply |
| | | b) Deleterious Constituents (IS:2386 Part 2) | If in doubt, one test |
| | | c) Alkali silicate reactivity (IS:2386 Part 7) | If in doubt, one test |

| | | | |
|---|---|---|---|
| 4) | Water | Normally potable water is good enough for making concrete<br>Determination of Impurities<br>- Suspended matter IS:3025 (Part 17)<br>- Organic IS:3025 (Part 16)<br>- Inorganic IS:3025 (Part 19)<br>- Sulphates (as SO3) IS:3025 (Part 24)<br>- Chlorides (as Cl) IS:3025 (Part 32) | If the quality is in doubt, samples taken from each source and tested at an approved test house |
| 5) | Concrete | Mix Design (for each work) | To be got approved from EE for cement content, W/C ratio and use of plasticizers, if any. |

**1803.17.2** *Tests/checks during construction*

The tests required to be carried out during construction shall be as given in **Table 1800.34**.

**Table 1800.34 Quality Control Tests during Construction**

| S. No. | Material/Work | Test/Check | Frequency |
|---|---|---|---|
| 1) | Fine and coarse aggregate | Moisture content (IS:2386 Part 3) | Once before commencement of work – each day |
| 2) | Cement (consumption) | Minimum quantity (Kg/m$^3$) | Daily |
| 3) | Concrete | a) Workability – slump cone test (IS:1199) | 2 tests/day |
| | | b) Cube Strength (IS:516) | Minimum of 6 cubes (3 each to determine 7 days and 28 days strength) to be cast every day) |
| 4) | Construction Joints | Fixing location before concreting and resumption of work | As and when work demands |
| 5) | Formwork | For stability, leakage of slurry, bulging etc. | Throughout concreting |

| | | | |
|---|---|---|---|
| 6) | Concreting | a) Transporting/placing segregation of concrete | Random check in each member |
| | | b) Precautions for hot weather or cold weather concreting | Once check before commencement of work |
| | | c) Compaction with vibrators | Regularly |
| 7) | Curing of concrete | Regular (till 28 days after casting) inspection | Daily |

### 1803.18 Tests on Formwork for Structures

### 1803.18.1 *Tests prior to construction*

The Quality Control tests to be carried out prior to construction shall be as given in **Table 1800.35**.

**Table 1800.35 Quality Control Tests Prior to Construction**

| S. No. | Test | Frequency |
|---|---|---|
| 1) | Thickness of Steel tubes | Before usage/Procurement |
| 2) | Dia of 'ballies' | -do- |
| 3) | Size of panels (steel sheets/timber planks) | -do- |
| 4) | Formwork if in reuse | To be approved by AE |
| 5) | Design of formwork | To be approved by EE |

### 1803.18.2 *Tests during construction*

The quality control tests to be carried out during construction shall be as given in **Table 1800.36**.

**Table 1800.36 Quality Control Tests during Construction**

| S. No. | Test | Frequency |
|---|---|---|
| 1) | Clamps for strength and stability of Formwork | Regular |
| 2) | Camber and Surface smoothness | At the end of erection work |
| 3) | Mortar tightness | Before concreting |
| 4) | Supporting system on ground (To prevent settlement and distribution of load) | Check before concreting |
| 5) | Safe access onto and about the formwork | Regularly during concreting |
| 6) | Height of panels for supporting structures and return walls | Check before concreting |

## 1803.19 Test on Steel Reinforcement

### 1803.19.1 *Tests prior to construction*

The Quality Control tests to be carried out prior to construction shall be as given in **Table 1800.37**.

**Table 1800.37 Quality Control Tests Prior to Construction**

| S. No. | Test | Frequency |
|---|---|---|
| 1) | Grade, percentage elongation and ultimate tensile strength (For culverts and small bridges)* (IS:432 Part 1 and IS:1786) | 3 samples from each supplier (certificate from an approved test house) |
| 2) | Pitch of the Ribs and Nominal Diameter | Random checking |
| 3) | Protection of Steel | Regularly |
| 4) | Substitution of bar sizes | Approval by AE/EE before execution of work |
| 5) | Detailing of reinforcement cages | Approval by AE/EE before execution of work |

* For Major Works, frequency of testing may be increased by the Engineer.

### 1803.19.2 *Tests during construction*

The Quality Control tests to be carried out during construction shall be as given in **Table 1800.38**.

**Table 1800.38 Quality Control Tests during Construction**

| S. No. | Test | Frequency |
|---|---|---|
| 1) | Bending and placing of reinforcement | Daily/Regularly |
| 2) | Splicing and welding | As and when such work is taken up |
| 3) | Tolerances (Spacing and cover) | Before concreting |

## 1803.20 Tests on Pipe Culverts

### 1803.20.1 *Tests prior to construction*

The quality control tests to be carried out prior to construction shall be as given in **Table 1800.39**.

**Table 1800.39 Quality Control Tests Prior to Construction**

| S. No. | Material/Work | Test/Check | Frequency |
|---|---|---|---|
| 1) | Bricks | As in Table 1800.29 | As in Table 1800.29 |
| 2) | Stones | As in Table 1800.31 | As in Table 1800.31 |
| 3) | Concrete Pipe | - Dimensions<br>- Manufacturing defects<br>- Tolerances (IS:458)<br>- Three edge bearing test (IS:3597) | At factory before delivery<br>Manufacturer's certificate |

**1803.20.2** *Tests/checks during construction*

The Quality control tests/checks to be carried out during construction shall be as given in **Table 1800.40**.

**Table 1800.40 Quality Control Tests during Construction**

| S. No. | Material/Work | Test/Check | Frequency |
|---|---|---|---|
| 1) | Bedding | - Materials (As per specification)<br>- Length, width and thickness<br>- Pre formation of cradle to lay pipes in bedding<br>- Top and bottom levels | While laying |
| 2) | Laying and Jointing of pipe | - Invert level<br>- Longitudinal gradient<br>- Spacing when 2 or more pipes are laid in a row or staggered columns.<br>- Jointing of pipes | Before back filling |
| 3) | Backfill | - Filling of trench on both sides (simultaneously)<br>- Tamping around pipe | During filling earth/ granular material Around pipe after laying |
| 4) | Cushion over pipes | Thickness | While filling |
| 5) | Brick/Stone Masonry for head walls | As per Specifications | As per specifications |
| 6) | Side slopes on Head walls | - Slope<br>- Stone pitching | Before construction of guard stones |

## 1803.21 Tests on RCC Slab Culverts and Minor Bridges

### 1803.21.1 *Tests prior to construction*

a) The quality control tests and checks to be carried out prior to construction shall be as given in **Table 1800.41**.

**Table 1800.41 Quality Control Tests Prior to Construction**

| S. No. | Material/Work | Test | Frequency |
|---|---|---|---|
| 1) | Cement, Fine/Coarse Aggregates and water and Concrete for Structures | Tests as in Table 1800.33 | As in Table 1800.33 |
| 2) | Steel Reinforcement (For culverts and small bridges) | Tests as in Table 1800.37 | As in Table 1800.37 |
| 3) | Plant and equipment and other arrangements for concrete production | a) Working condition of concrete mixers including standby arrangement<br>b) Measuring boxes/scales for cement, fine and coarse aggregates<br>c) Standard measuring cans (1/2, 1, 2, 5 litre capacity) for water<br>d) Needle, plate and screed vibrators<br>e) Arrangements for protection of concrete in hot, cold and rainy weather<br>f) Tools and equipment for finishing and curing.<br>g) Formwork | Check by AE before commencement of concreting |

b) Other checks to be done on 'Manufactured items' prior to construction shall be as given in **Table 1800.42**.

**Table 1800.42 Quality Control Tests Prior to Construction**

| S. No. | Material/Product | Test/Check | Frequency |
|---|---|---|---|
| 1) | Elastomeric bearings (IRC-83 part II) For Spans > 10 m | Approved Test house report obtained by Manufacturer. | To be approved by AE/EE before procurement |
| 2) | Expansion Joints (IRC:SP:70) | Performance report (To be furnished by manufacturer) | -do- |
| 3) | Shear connectors (For composite bridges) | Dia, length and yield strength | -do- |
| 4) | Plasticizer (If used to improve workability of concrete) | As per Manufacturer's test reports. | -do- |

**1803.21.2** *Tests/checks during construction*

The Tests/Checks to be carried out during construction shall be as given in **Table 1800.43**.

**Table 1800.43 Quality Control Tests during Construction**

| S.No. | Material/Work | Test/Check | Frequency/Stage |
|---|---|---|---|
| 1) | Concrete for Structures | For constituents<br>As in Table 1800.34 | As in Table 1800.34 |
| 2) | Concreting | | |
| | - For Foundation | Dewatering, before laying of foundation concrete | For each foundation work |
| | - For Substructure | Form panel size and jointing to prevent bleeding | For each work |
| 3) | Cube Strength Results | Analysis of Test results | During construction of substructures/super-structures separately |
| 4) | Form work | Tests as in Table 1800.36 | As in Table 1800.36 |
| 5) | Reinforcement cage | a) Dia and spacing of Reinforcements in cage as per drawing | Before commencement of concreting |
| | | b) Size and placement of briquettes for supporting the reinforcements i.e. to provide bottom and side covers | - do - |
| | | c) Cleaning rust on reinforcements with wire brushing | Before placement and compaction of concrete |
| | | d) Other checks as per Table 1800.38 | |

| | | | |
|---|---|---|---|
| 6) | All concrete works | a) Temperature Control & Control of W/C ratio (As per time & season of work) of mix | Regularly |
| | | b) Workability (IS:1199) | Twice in a day. |
| | | c) Compaction | Ensure compaction by needle vibrator |
| | | d) Curing | To commence 24 hrs after casting. |
| 7) | Expansion Joint assemblies | Installation as per Manufacturer's specification | At each Joint location |
| 8) | Sealants | To be installed as per Manufacturer's specification. | After hardening of concrete |
| 9) | Kerbs, Drain pipes Railings/Parapets | - Separate form work<br>- Spacing<br>- Dimensions | As and when work is taken up |
| 10) | Elastomeric bearings | Correct positioning on pedestals | Before concreting |

## 1803.22 Tests on Stones and Apron for Protection Works

### 1803.22.1 *Tests prior to construction*

The Quality Control tests and checks to be carried out prior to construction shall be as given in **Table 1800.44**.

**Table 1800.44 Quality Control Test Prior to Construction**

| S. No. | Test/Check | Frequency |
|---|---|---|
| 1) | Size and weight of stones in apron/slope/flooring etc. | At quarry site before procurement |
| 2) | Wire crates (Size and mesh size) | Before procurement |
| 3) | Cement concrete blocks (Weight and Size) | Before procurement |
| 4) | Gradation of Filter media | Before procurement |

### 1803.22.2 *Tests during construction*

The quality control tests and checks to be carried out during construction shall be as given in **Table 1800.45**.

**Table 1800.45 Quality Control Tests during Construction**

| S. No. | Test/Check | Frequency |
|---|---|---|
| 1) | Laying of Filter granular material | Daily check for workmanship |
| 2) | Laying boulders for<br>- Apron<br>- Pitching on Slopes<br>- Toe protection<br>- Wire crates | Daily check for uniformity in workmanship |
| 3) | Mortar for Joints<br>a) Mix proportions, (control on quality of cement/ lime by weight | Each batch |
| | b) Consistency and water retentivity (IS:2250) | As required |
| | c) Compressive strength (IS:2250) | 3 samples of cubes where specified |
| 4) | Laying of brick stones in flooring | Daily check for workmanship |
| 5) | Curtain wall | Daily check for workmanship |
| 6) | Drain (Chute, Road side, Hill side and Catch water) | Daily check for workmanship |

### 1803.23 Tests on Cement Concrete Causeways and Submersible Bridges

The quality control tests/checks listed here cover causeways and submersible bridges where in materials such as brick or stone masonry, plain or reinforced concrete are used. The openings in causeways could be of concrete pipes or rectangular/arch semicircular vents in RCC.

### 1803.23.1 *Tests prior to construction*

The quality control tests and checks to be carried out prior to construction shall be as given in **Table 1800.46**.

**Table 1800.46 Quality Control Tests Prior to Construction**

| S. No. | Material | Test/Check | Frequency |
|---|---|---|---|
| 1) | Bricks | As in Table 1800.29 | Table 1800.29 |
| 2) | Stones | As in Table 1800.31 | Table 1800.31 |
| 3) | Concrete Materials | As in Table 1800.33 | Table 1800.33 |
| 4) | Stainless Steel bars (For submersible bridges) | Rust, acid and heat resistance (IS:6603) | Before procurement |
| 5) | Steel reinforcement | As in Table 1800.37 | Table 1800.37 |
| 6) | Cement pipes (If used) | As in Table 1800.39 | Table 1800.39 |

| | | | |
|---|---|---|---|
| 7) | Plant equipment for production of concrete | As in Table 1800.41 | Table 1800.41 |
| 8) | Pavement Materials | Sub-base (Table 1800.6)<br>WBM (Table 1800.12)<br>Cement concrete (Table 1800.33) | Table 1800.6<br>Table 1800.12<br>Table 1800.33 |

**1803.23.2** *Tests during construction*

The Quality Control Tests/checks to be carried out during construction shall be as given in **Table 1800.47**.

**Table 1800.47 Quality Control Tests during Construction**

| S. No. | Material/Work | Test/Check | Frequency |
|---|---|---|---|
| 1) | All concrete works | a) Workability (IS:1199)<br>b) Cube strength (IS:516)<br>c) Curing | As per Table 1800.43 |
| 2) | Concrete for foundation substructure, super-structure (For submersible bridges) | a) Dewatering<br>b) Form panels,<br>c) Jointing,<br>d) Cover to reinforcements | As per Table 1800.43 |
| 3) | Form Work | Design, Erection, Camber, etc. | As per Table 1800.36 |
| 4) | Reinforcement cage | Dia, spacing, cover as per drawings | - do - |
| 5) | Kerbs, drain pipes railings /parapets | As indicated in drawings | - do - |
| 6) | Bearings & Expansion Joints | Manufacturer's Specification | - do - |
| 7) | Jointing of pipes & bedding | As per Table 1800.40 | During construction |
| 8) | Cement Concrete Pavement (Additional tests) | As per Table 1800.49 (Items 5,6,7 & 8) | Table 1800.49 (Items 5,6,7 & 8) |
| 9) | Equipment for handling pipes (prior to lowering) | - Adequacy of chain pulley block<br>- Stability of Tripod arrangement etc. | Check by AE |

### 1803.24 Tests on Plain Concrete Pavement

### 1803.24.1 *Tests prior to construction*

The quality control tests and checks to be carried out during construction shall be as given in **Table 1800.48**.

**Table 1800.48 Quality Control Tests Prior to Construction**

| S. No. | Type of Test | Frequency |
|---|---|---|
| 1) | Cement | As in Table 1800.33 |
| 2) | Fine Aggregates | As in Table 1800.33 |
| 3) | Coarse Aggregates | As in Table 1800.33 |
| 4) | Water | Once for each source, subsequently in case of doubt. |
| 5) | Admixture<br>- Chemical (For workability) (IS:6925 & IS:9103)<br>- Mineral (Flyash) (IS:3812) | Manufacturer's certificate before procurement<br>- do - |
| 6) | Dowel bars (Plain steel) IS:432 (Part I) | Tests on 3 samples to determine yield strength |
| 7) | - Premoulded Joint Filler (IS:1838) or<br>- Joint Sealing Compound (IS:1834) | Manufacturer's Certificate<br>-do- |
| 8) | Plants equipment and tools | As per contract |
| 9) | Concrete mix design for cement content, w/c ratio and dosage of plasticizers for the specified design strength. | To be approved by EE |
| 10) | Granular Sub-base | Table 1800.6 |
| 11) | Trial length | To be approved by EE before regular work. |

### 1803.24.2 *Tests during construction*

The tests and checks to be carried out during construction shall be as given in **Table 1800.49**.

Table 1800.49 Quality Control Tests during Construction

| S. No. | Tests/Check | Frequency |
|---|---|---|
| 1) | Subgrade and Subbase | As in Tables 1800.5 and 1800.7 |
| 2) | Gradation and moisture content of aggregate for CC pavement | Minimum once per day. |
| 3) | Concrete workability (Slump cone tests IS:1199) | One test per 3 cum of concrete at paving site or one test for each dumper laid at plant site. |
| 4) | Strength of Concrete (IS:516) | Minimum 6 cubes and 6 beams (3 each for 7 day & 28 day strength) per day. |
| 5) | Straightness of side forms (steel) (For paralleling and possible settlement and securing position before concreting) | To be checked daily |
| 6) | Size, spacing, paralleling of Dowel bars and location of different joints | To be checked prior to casting of concrete at the location. |
| 7) | Batching and Mixing of materials | Check for measurements and proper mixing |
| 8) | Hot/Cold weather concreting including compaction | Checks Regularly |
| 9) | Compaction equipment (Needle, Screed and Plate vibrators) | For continuous working and standby arrangement |
| 10) | Separation membrane (thickness and laying) | Prior to laying of pavement concrete |
| 11) | Levels and Alignment | |
| | i) Level tolerance | To be checked for each day's work Regularly |
| | ii) Surface Regularity (Transverse and Longitudinal including camber/cross slope) | |
| | iii) Width of pavement and position of paving edges | To be checked for each day's work Regularly at grid points |
| | iv) Pavement thickness | To be checked for each day's work |
| | v) Alignment of joints | -do- |
| | vi) Depth of Dowel Bars | -do- |
| | vii) Texturing and Edging | -do- |

## 1803.25 Tests on Roller Compacted Concrete Pavement

### 1803.25.1 *Tests prior to construction*

The Quality Control tests and checks to be carried out prior to construction shall be as given in **Table 1800.50**.

**Table 1800.50 Quality Control Tests Prior to Construction**

| S. No. | Tests | Frequency |
|---|---|---|
| 1) | Materials for concrete | As in Table 1800.48 |
| 2) | Concrete Mix design (With and without flyash) | Approval by EE for cement content w/c ratio and use of plasticizers |
| 3) | Plants, Equipment and tools | As per contract |
| 4) | Trial length before commencement of regular work | Approval by EE |
| 5) | Granular Sub base | As in Table 1800.6 |
| 6) | Design Parameters (Grade of concrete, width, thickness and details of joints) | As per construction drawings. |

### 1803.25.2 *Tests during construction*

The quality control tests and checks to be carried out during construction shall be as given in **Table 1800.51**.

**Table 1800.51 Quality Control Tests during Construction**

| S. No. | Tests/Check | Frequency |
|---|---|---|
| 1) | Gradation and moisture content of aggregates | As in Table 1800.49 |
| 2) | Batching and mixing of materials | Check for measurements and proper mixing |
| 3) | Workability, zero slump and insitu density of RCCP | One test for 3 cum of concrete |
| 4) | Insitu density of trial length by sand replacement method (IS:2720) | Three tests for each 2000 sqm or part thereof. |
| 5) | Subgrade and Subbase | As in Tables 1800.5 and 1800.7 |
| 6) | Strength of Concrete (IS:516) | As in Table 1800.49 |
| 7) | Side forms | As in Table 1800.49 |
| 8) | Transverse Contraction Joints (width and depth) | 18-24 hours after laying |

### 1803.26 Tests on Rectangular Concrete Block Pavement

#### 1803.26.1 *Tests prior to construction*

The quality control tests and checks to be carried out prior to construction shall be as given in **Table 1800.52**.

**Table 1800.52 Quality Control Tests Prior to Construction**

| S. No. | Tests/Check | Frequency |
|---|---|---|
| 1) | Materials for concrete | As in Table 1800.48 |
| 2) | Concrete Mix Design | For approval by EE |
| 3) | Grading for bedding and Joint filling sand | For approval by EE |
| 4) | Size and Compressive Strength of Paving blocks | As per drawings |
| 5) | Subgrade and Subbase | As in Tables 1800.4 and 1800.6 |
| 6) | Trial length before commencement of regular work | Approval by EE |
| 7) | Design parameters (Joints Details, Pattern of laying and End restraints) | As per drawing |
| 8) | Manufacturing machine or Semi mechanized method for blocks and Vibrating plate compactor | As per contract |

#### 1803.26.2 *Tests during construction*

The Quality Control Tests and checks to be carried out during construction shall be as given in **Table 1800.53**.

**Table 1800.53 Quality Control Tests during Construction**

| S. No. | Tests/Check | Frequency |
|---|---|---|
| 1) | Sub-grade and Sub-base | As in Tables 1800.5 and 1800.7 |
| 2) | Compressive Strength of concrete (IS:516) | As in Table 1800.49 |
| 3) | Pattern of laying of blocks and End restraints (As per drawings) | At random |
| 4) | Earthen shoulders (Width and camber) | At random |
| 5) | Width of Joints between blocks | At random |
| 6) | Tolerances (Level tolerance & Surface Regularity) | At random |

## 1803.27 Tests on Interlocking Concrete Block Pavement

### 1803.27.1 *Test prior to construction*

The Quality Control Tests and checks to be carried out prior to construction shall be as given in **Table 1800.54**.

**Table 1800.54 Quality Control Tests Prior to Construction**

| S. No. | Tests/Check | Frequency |
|---|---|---|
| 1) | Concrete materials | As in Table 1800.48 |
| 2) | Grading for bedding and Joint filling sand | For approval by EE |
| 3) | Mix Design for concrete | For approval by EE |
| 4) | Base Course | As in Tables 1800.4 and 1800.6 |
| 5) | Trial length of 30 m before commencement of work | For Approval by EE |
| 6) | Block size and thickness | 5 samples selected at random for every 1000 specimens. For approval by AE |
| 7) | Water absorption and compressive strength of blocks | 5 blocks selected at random for every 500 blocks. For approval by AE |

### 1803.27.2 *Tests during construction*

Quality control tests and checks to be carried out during construction shall be as given in **Table 1800.55**.

**Table 1800.55 Quality Control Tests during Construction**

| S. No. | Tests/Check | Frequency |
|---|---|---|
| 1) | Sub-grade and sub-base | As in Tables 1800.5 and 1800.7 |
| 2) | Dimensions and Tolerances of paving blocks | As specified. At random |
| 3) | Paving pattern | Approval by EE before commencement of work |
| 4) | Paving and compaction of blocks | Regularly |
| 5) | Surface Regularity<br>a) Tolerances for lines, levels and grades<br>b) Longitudinal and Transverse profile | Random check |
| 6) | Compressive Strength of concrete of blocks | As specified |

# 1900

# MAINTENANCE

## 1901 GENERAL

The Specifications shall apply to all items of road maintenance works as required to be carried out under the Contract or as directed by the Engineer. The works shall be carried out in conformity with the relevant Specifications to the required level, grade and lines using approved materials. The works can be carried out using light duty machinery or manual means ,if approved by the Engineer, provided the quality of the end product meets the specified standard. In execution of maintenance works, a reference is made to MORT&H "Manual for Maintenance of Roads" published by IRC, and IRC:82 "Code of Practice for Maintenance for Bituminous Surfaces of Highways" for guidance and compliance wherever applicable. Wherever the Specifications are not given for an item, good engineering practice shall be adopted in execution of maintenance works to the satisfaction of the Engineer.

## 1902 RESTORATION OF RAIN CUTS

### 1902.1 Scope

The work shall consist of earthwork for restoration of rain cuts in the embankment and shoulders, using suitable material, and compacting the same as directed by the Engineer.

### 1902.2 Materials

The material used for restoration of rain cuts shall consist of soil as per requirements of Section 300 of these Specifications.

### 1902.3 Construction Operation

The area affected by rain cuts shall be cleared of all loose soil and benched. The width of the benches shall be at least 300 mm and they shall extend continuously for a sufficient length. The height of the benches shall be in the range of 150-300 mm.

Fresh material shall be deposited in layers not exceeding 250 mm loose thickness and compacted so as to match with the benching at a moisture content close to the optimum. Compaction shall be carried out using suitable equipment such as plate compactors and rammers or by suitable implements handled manually. The finished work shall conform to alignment, levels and slopes as indicated in the drawings or as directed by the Engineer.

### 1902.4 Measurements for Payment

The earthwork for restoration of rain cuts shall be measured in cubic metres.

### 1902.5 Rate

The Contract rate for the item of earthwork for restoration of rain cuts shall be payment in full compensation for carrying out the required operation including full compensation for:

i) supply of material including all leads and lifts and the cost of arranging land for borrow pits;

ii) setting out;
iii) removal of loose material from the rain cuts;
iv) benching of old earthwork;
v) compacting after adding required quantity of water; and
vi) all labour, material, tools, equipment and incidentals to complete the work as per these Specifications.

## 1903 MAINTENANCE OF EARTHEN SHOULDER

### 1903.1 Scope

The work of maintenance of earthen shoulder shall include making up the irregularities/loss of material on shoulder to the design level and crossfall by adding fresh approved selected soil and compacting it with appropriate equipment or to strip excess soil from the shoulder surface as per the requirement of this Specification and as directed by the Engineer. The earthen shoulders shall be kept free from uncontrolled growth of vegetation, bushes and other objects which impede the free drainage from pavement.

### 1903.2 Material

The material to be added to the shoulder, if required, shall be a select soil as per requirements of Section 300 of these Specifications.

### 1903.3 Construction Procedure

This work shall involve:

i) making up of the earthen shoulder by adding extra soil and compacting the same; and/or
ii) stripping a layer of soil to achieve the required grade and level.
iii) clearance of vegetation, bushes and other objects.

Wherever extra earth is required to be added, the earthen shoulder shall be stripped and loosened to receive fresh soil. The deficiency of thickness shall be made up in layers of loose thickness not exceeding 250 mm. Water shall be added, if required, to attain the optimum moisture content and the layer compacted by 80 to 100 kN smooth wheel roller, vibratory roller, hand roller, plate vibrator or hand rammer to obtain at least 100 percent of the maximum dry density in accordance with IS:2720 (Part 7). The finished surface shall have the specified cross slope and line in accordance with the drawing. The side slopes shall be trimmed to the specified slope with the help of tractor with grader attachment or manual methods using hand tools.

Wherever the earth is required to be excavated from the shoulder, this shall be done either using equipment like tractor with grader attachment or by manual means using hand tools. The resulting surface shall be uniform and have a field density of at least 100 percent of maximum dry density obtained in accordance with IS:2720 (Part 7). If the surface is not uniformly compacted, it shall be excavated to a depth of 150 mm and the soil mixed with water if required and compacted at a moisture content close to the optimum to achieve 100 percent of maximum dry density as stated above and making sure that the camber or crossfall as required is provided.

Vegetation, bushes and other objects which impede the drainage from pavement shall be cleared by suitable tools and equipment.

### 1903.4 Measurements for Payment

Maintenance of earthen shoulder shall be measured in square metres.

### 1903.5 Rate

The Contract unit rate for maintenance of earthen shoulder shall be payment in full compensation for:

i) clearances of vegetation, bushes and other objects;

ii) stripping, loosening of earthen shoulder soil and dressing it to proper profile before placement of extra select soil;

iii) furnishing earth required for making up of shoulders including all leads and lifts, compaction to the required density and arranging land for borrow pits;

iv) excavation of earth as required and disposal of the earth at the location approved; and

v) all labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1904 MAINTENANCE OF BITUMINOUS SURFACE ROAD

### 1904.1 Scope

The scope and type of maintenance work to be carried out shall be in accordance with the provisions of the Contract or as directed by the Engineer.

Maintenance treatments required under the Contract or instructed by the Engineer may include pot-hole and patch repair, surface dressing and 20 mm open graded premix carpet.

The aggregates, bitumen and other construction materials to be used for repair and maintenance work shall conform to the requirements of the relevant specifications for the original construction.

Traffic control during maintenance operations shall conform to the requirements of Section 100 of these Specifications.

## 1904.2 Filling Pot-holes and Patch Repairs

### 1904.2.1 *Scope*

This work shall include repair of pot-holes and patching of all types of bituminous pavement.

The work shall include the removal of all failed material in pavement courses up to the affected depth, the trimming of the completed excavation to provide firm vertical faces; back filling of the excavated area in layers to the specification as per original construction; application of prime/ tack coat on the base and the sides of excavations prior to placing of any bituminous materials and compaction, trimming and finishing of the surfaces of all patches to form a smooth continuous surface, level with the surrounding road.

### 1904.2.2 *Materials*

All materials used for the pot-hole and patch repair of bituminous surface and underlying layers shall be in accordance with these Specifications and shall be of the same type as specified for the original construction or higher.

The mixture to be used in bituminous patching shall be either a hot or cold mix in accordance with the appropriate clauses of these Specifications. Materials used for patching shall not have a porosity greater than the adjacent previous constructions. Non-bituminous materials shall not be used for patching existing bituminous layers.

Cold bituminous mixes using emulsion or cut back shall conform to the relevant IRC Specifications and "Guidelines for Construction and Maintenance of Bituminous Roads Using Cold Mix Technology" (IRC:SP:100). These types of mixes can be prepared and stored for a period of six months or so and can be readily used during monsoon also.

### 1904.2.3 *Preparation of the area for pot-hole and patch repair*

The work shall be carried out as per Section 500 of these Specifications.

### 1904.2.4 *Backfilling operation*

The work shall be carried out as per requirements of Section 500 of these specifications.

### 1904.2.5 *Measurements for payment*

Filling of pot-hole and patch repair work shall be measured in square metres.

### 1904.2.6 *Rate*

The Contract unit rate for filling of pot-hole and patch repair shall be payment in full compensation for:

i) supplying all materials required with all leads and lifts;

ii) all works involved including excavation, trimming, backfilling with non-bituminous layers required, application of tack coat,priming with emulsion or cutback and backfilling with the specified bituminous materials;

iii) all labour, plants, tools, equipment, disposal of surplus material and incidentals to complete the work in accordance with the Specifications.

## 1905 MAINTENANCE OF CEMENT CONCRETE ROAD

### 1905.1 Repair of Joint Grooves

**1905.1.1** *Scope*

The work shall consist of repair of spalled joint grooves of contraction joints, construction joints, longitudinal joints and expansion joints in the concrete pavement using epoxy mortar or epoxy concrete as directed by the Engineer.

**1905.1.2** *Materials*

The type/grade of epoxy compatible with the coefficient of thermal expansion of concrete shall be used with either processed fine aggregates or fine stone chips to produce a dry mix for reparing spalled or damaged edges.

**1905.1.3** *Repairing procedure*

Spalled or broken edges shall be shaped neatly with a vertical cut with chisels in the shape of rectangle. Small pneumatic chisels may also be used , provided the depth of cutting can be controlled. The depth of the cut shall be the minimum to effect repair. After shaping the spallled area, it shall be cleaned and primed. The epoxy mortar/concrete is then applied using hand tools like trowels, straight edges, brushes etc. The repaired edge shall be in line with the joint groove and shall be flush with the concrete slabs. During the repair work, any damaged noticed to the joint sealant shall be made good by raking out the affected portion and resealing.

**1905.1.4** *Traffic*

Although the epoxy mixes set in 2-3 hours time, it is desirable to divert the traffic for 12 hours or as per the recommendation of the manufacturer.

**1905.1.5** *Measurements for payment*

Repair of joint grooves shall be measured in linear metres.

**1905.1.6** *Rate*

The contract unit rate for repair of joint grooves with epoxy mortar or epoxy concrete shall be payment in full compensation for;

i) Supply and application of epoxy primer, epoxy mortar or epoxy concrete;

ii) All labour, tools, equipment and incidentals to complete the work in accordance with the specifications.

## 1905.2 Repair of Sealant

### 1905.2.1 *Scope*

The work shall consist of repair of sealant of contraction, construction, longitudinal or expansion joints including removal of the existing sealant and resealing the joint with fresh sealant material as directed by the Engineer.

### 1905.2.2 *Material*

Sealant material to be replaced shall be either hot poured rubberized bitumen as per IS:834 or cold poured polysulphide sealant as per IS:11433 (Part I). As per the recommendation of the manufacturer, appropriate type of primer shall be applied.

### 1905.2.3 *Repairing procedure*

The existing sealant shall be raked out with the help of metal raker such that most of the sealant is removed. Subsequently, the sealant stuck to the sides of the grooves shall be removed thoroughly either by using saw cutting machine so that grooves may be widened by one mm or by sand blasting. In no case shall the old sealant be present during resealing operation. If joint grooves are found inadequate in depth, they shall be deepened as directed by the Engineer. The edges of the grooves shall be chamfered. Any spall of the joints shall be made good by epoxy mortar.

Before commencing the sealing operation, compressed air shall be used to clean the joint grooves. A heat resistant, paper backed compressible debonding strip or tape and backer rod shall be inserted. Before sealing the groove, the temporary backer road initially provided for blocking the ingress of dirt and soil etc. shall be removed. Cotton rope covered with strip of synthetic rope slightly higher in diameter than the width of the groove shall be forced to the bottom of groove. The purpose of this backer rod is to prevent the leakage of sealant into the crack under the sealant reservoir and also to debond the sealant from itself (backer rod). Sealant may be poured either using hand held pourer or using mechanized sealing machines/pump/gun. Sealant should not be heated directly but in double jacketed machine. All precautions and arrangements shall be taken not to spill the sealant on to the concrete pavement. The sealant may be poured to a depth of 3 mm from the pavement surface.

### 1905.2.4 *Measurements for payment*

Repair of joint sealant shall be measured in linear meters.

### 1905.2.5 *Rate*

Contract unit rate for repair of joint sealant shall be in full compensation for :

i) Removal of old sealant, regrooving or sand blasting the sealing groove and placing of debonding strip or tape.

ii) All labour, tools, equipment and incidentals to complete the work in accordance with the specifications.

## 1906 MAINTENANCE OF GRAVEL ROAD

### 1906.1 Scope

The work of maintenance of gravel road shall include grading, dragging, patching, regravelling and use of dust palliatives and include making up the loss of profile, rectifying corrugated surface, filling up of depressions, pot-holes, ruts and erosion gullies by adding fresh approved material and compacting it with appropriate equipment or to strip excess of material from the road surface as per the requirements of this Specification and as directed by the Engineer. Regravelling is a periodic maintenance operation. The cross section of the road after the maintenance operation shall be as specified. In execution of maintenance works of gravel roads, reference may be made to IRC:SP:77 "Manual for Design, Construction and Maintenance of Gravel Roads" for guidance and compliance as applicable.

### 1906.2 Materials

The material to be added to the gravel road surface where required, shall be a select material as per requirements of Section 400 of these Specifications.

### 1906.3 Construction Procedure

### 1906.3.1 *Grading*

Grading shall be carried out by tractor-towed grader. The gravel road surface to be graded shall be prepared by patching of large potholes or depressions and draining out areas of standing water. It may be necessary to scarify the existing surface to cut to the bottom of any surface defects and loosen the material for reshaping. The grading operation shall be carried out as per IRC:SP:77.

### 1906.3.2 *Dragging*

Dragging shall be required only when the pavement is structurally sound and the loose running course is less than 25 to 30 mm depth. Dragging shall be done by using specially made drags towed by agricultural tractors. The type of drag to be used shall be according to the condition of the road and as per the guidelines given in IRC:SP:77. Drags shall be towed at a speed between 5 km/hour and 10 km/hr. The dragging operation shall be carried out as per the details given in IRC:SP:77.

### 1906.3.3 *Patching or filling up local depressions, ruts, pot-holes and erosion gullies*

The repair work of filling up the local depressions, ruts, pot-holes and erosion gullies shall be carried out by replacing or adding new surface material as per requirements of Section 400 and compacting it. The affected area shall first be cleaned of all loose material, brought to a regular rectangular shape and the bottom surface compacted by hand rammers. Standing water, if any, shall be cleared and the area shall be made dry. The area thus prepared shall be filled up with gravel as per Section 400 of these Specifications, sprinkled with water, where required, to bring the moisture content close to the optimum and compacted as per Section 400 of these Specifications. The patching operation shall be carried out as per IRC:SP:77.

### 1906.3.4 *Regravelling*

Regravelling is a periodic maintenance operation to be taken up before any significant reduction in base thickness takes place. Regravelling may also be carried out to rectify the defects of loss of shape, ruts, potholes in large areas, erosion gullies. Where regravelling is to be carried out as a periodic maintenance measure, the existing road surface shall be graded with a tractor towed grader to provide a firm regular shape and camber. The graded surface shall be watered and rolled. After the initial grading by the grader and to be watered to bring moisture content close to the optimum moisture content. The material shall be graded to produce the specified camber and compacted by roller as per requirements of Section 400 of these Specifications,and additional gravel 25 mm to 75 mm in loose thickness, as specified and meeting the requirements of Section 400 of these specifications shall be spread after scarifying the old surface. The work shall be carried out as per IRC:SP:77.

### 1906.3.5 *Use of dust palliatives*

Dust palliatives are to be used to control the generation of dust on gravel roads. Dust palliatives are to be used as per provisions of IRC:SP:77.

### 1906.4 Measurements for Payment

The routine maintenance works of grading, dragging, patching for making up the loss of profile, rectifying corrugated surface, filling up of depressions, potholes and erosion gullies, and use of dust palliatives shall be measured in square metres. The periodic maintenance work of regravelling shall, however, be measured in cum.

### 1906.5 Rate

The Contract unit rate for routine maintenance of gravel road shall be payment in full compensation for:

a) supply of gravel including all leads and lifts;
b) removal of loose material from affected areas;
c) compaction after adding required quantity of water;
d) all labour, material, tools, plants, equipment and other incidentals to complete the work as per these Specifications.

The Contract unit rate for periodic maintenance by way of regravelling shall be as per Section 400 of these Specifications.

## 1907 MAINTENANCE OF WBM ROAD

### 1907.1 Scope

The work of maintenance of WBM road shall include filling up of pot-holes, ruts and rectifying corrugated surface, damaged edges and ravelling. It also includes the periodic maintenance measure of surface renewal as directed by the Engineer or as provided in the contract.

### 1907.2 Materials

The materials to be added including coarse aggregate, screenings and binding material shall meet the requirements of Section 400 of these Specifications and shall be the same type and grading as of original construction or as specified.

### 1907.3 Construction Procedure

#### 1907.3.1 *Filling up pot-holes*

All loose material up to the firm base from a pot-hole shall be taken out. The sides of the hole shall be kept vertical and the affected area made into a regular rectangular shape. The cleared space shall then be filled with stone aggregate. The surface of the stone aggregate shall slightly protrude above the surrounding area. The screenings and binding material shall be spread manually over the aggregate. The aggregate layer shall then be compacted by hand rammers. The stone aggregate layer shall be watered and the layer again compacted by hand rammers, followed by road roller.

#### 1907.3.2 *Filling up ruts*

The rutted portion shall first be cleaned of all loose material and sprinkled with water. Scarification and removal of stones shall be done to an approximate rectangular section with flat bottom and vertical sides. The rectangular section thus prepared shall be filled with salvaged and fresh aggregates as required and rolled with the addition of screenings, gravel and watering, finally providing a 6 mm sand layer.

#### 1907.3.3 *Rectifying corrugated surface*

The excess binding material deposited in ripples shall be immediately removed by dragging or brooming. If, however, corrugations have developed in the WBM course itself, a renewal layer shall be provided as per Section 400 of these Specifications, after properly scarifying the corrugated surface.

#### 1907.3.4 *Repairing damaged edges*

The damaged portions of the edges shall be removed and renewed with fresh material. Rolling of the edge and shoulder shall be carried out simultaneously and cross-profile of the shoulder remedied by grading.

#### 1907.3.5 *Rectifying ravelled surface*

Where, ravelling is detected early by the presence of fine hair cracks, the tendency for ravelling can be remedied by blending with a good binding material and watering the surface. If however, ravelling is quite prominent, the repair shall be carried out by resurfacing. Prior to resurfacing, the old surface shall be scarified, fresh material added and rolling of the surface carried out as followed for new construction (Refer Section 400 of these Specifications).

#### 1907.3.6 *Periodic surface renewal*

Renewal of WBM surface shall be carried out by providing layer of 75 mm thickness of WBM in accordance with Section 400 of these Specifications. The existing surface shall first be cleaned of all dust and caked mud by wire brushes and brooms. After moistening, the surface shall be scarified and the salvaged materials screened. The salvaged material together with fresh additional material (grading 3), as required shall be spread and dry rolled with a power roller. After application of screenings and spreading of binding material, rolling shall be carried out as per Section 400 of these Specifications. A 6 mm layer of coarse sand shall be spread and light sprinkling of water shall be carried out for 2 to 3 days before opening to traffic. Shoulder shall be constructed simultaneously by adding additional earth/shoulder material as required. No traffic shall be allowed until the water bound macadam has dried and set.

### 1907.4 Measurements for Payment

The routine maintenance works comprising filling up of pot-holes, ruts and rectifying corrugated surface, damaged edges and ravelling shall be measured in square metres. The periodic maintenance work of surface renewal shall, however, be measured in cubic metres.

### 1907.5 Rate

The contract unit rate for routine maintenance of WBM road shall be full compensation for:

a) supply of materials for WBM, including all leads and lifts;
b) removal of loose material from affected areas;
c) cleaning of the surface;
d) disposal of unused material as directed by the Engineer;
e) compaction after adding required quantity of water;
f) all labour, material, tools, equipment and incidentals to complete the work as per these Specifications.

The Contract unit rate for periodic maintenance work of surface renewal with WBM shall be as per Section 400 of these Specifications.

## 1908 MAINTENANCE OF DRAINS

### 1908.1 Scope

The work shall consist of erosion repair, clearing, cleaning, reshaping, regrading and deepening of side drains as well as catch water drains including repairs to damaged lining where specified, to ensure that drainage channels remain free of obstruction and retain their intended cross sections and grades as directed by the Engineer.

### 1908.2 Maintenance Operation

The affected length of side drain or catch water drain shall be cleared of all growth of vegetation, debris, loose soil/silt and the same reshaped, regraded to the intended cross sections and grades with the excavated useful earth available from regrading or with suitable borrowed soil in accordance with Section 300 of these Specifications.

The damaged lining shall be restored to original specification in accordance with the relevant clauses of these Specifications.

### 1908.3 Measurements for Payment

The maintenance of side drain and catch water drain shall be measured in linear metres.

Repairs and restoration of lining of drainage channels shall be measured separately in square metres.

### 1908.4 Rate

The Contract unit rate for maintenance of drain or repairs to damaged lining shall be payment in full compensation for all labour, materials, tools, equipment and incidentals to carry out the required maintenance operations and complete the work in accordance with these Specifications.

## 1909 MAINTENANCE OF CULVERTS

### 1909.1 Scope

The work shall consist of routine activities of clearing, cleaning, erosion repair, repairs to cracks, parapet walls, protection works and invert of culverts, as directed by the Engineer.

### 1909.2 Materials

All materials used for the repairs to cracks, protection works, parapet walls shall be in accordance with the Specifications and shall be of the same type as specified for the original construction conforming to Sections 1100, 1200, 1300 and 1400 of these Specifications as relevant.

### 1909.3 Maintenance Procedure

This work shall involve the following operations and shall be carried out in accordance with the relevant clauses of these Specifications or as directed by the Engineer:

- i) the culvert openings and catch water pits shall be cleared and cleaned of all debris, sand and silt, vegetation without causing damage to any part of the structure;
- ii) erosion repair;
- iii) repairs to cracks. All cracks shall be cleaned and filled with cement slurry or a suitable crack sealing mortar as directed by the Engineer and properly cured.
- iv) repairs to protection works. Damaged portion shall be repaired in accordance with Section 1300 of these Specifications.

The debris, sand and silt after removal from the culvert and catch water pit shall be dumped away from the water channel as directed by the Engineer.

### 1909.4 Measurements for Payment

The maintenance for the culverts shall be measured in number of Hume pipe or slab culverts.

### 1909.5 Rate

The Contract unit rate for maintenance of culvert shall be payment in full compensation for:

i) supplying of cement, sand, other materials and all operations to repair the cracks;

ii) resetting the existing disturbed boulders and supply of additional boulders for repair to protection works in U/S and D/S sides of the culverts;

iii) removal and disposal of all debris and vegetation etc.

iv) all the labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1910 MAINTENANCE OF CAUSEWAYS

### 1910.1 Scope

The work shall consist of routine activities of minor pavement surface repair, replacing guide posts, repairing flood gauges and protection works as directed by the Engineer.

### 1910.2 Materials

All materials used for the repairs to surface, flood gauges and protection works shall be in accordance with the Specifications and shall be of the same type as specified for the original construction conforming to Section 1100 of these Specifications.

### 1910.3 Maintenance Procedure

This work shall involve following operations and shall be carried out in accordance with the relevant clauses of these Specifications:

i) minor pavement surface repair;

ii) replacing guide posts;

iii) repair of flood gauges;

iv) removal of debris and boulders from U/S and D/S of the causeway and using boulders in protection works;

The debris and surplus boulders after removal from the vicinity of the causeway shall be dumped away from the water channel as directed by the Engineer.

### 1910.4 Measurements for Payment

The maintenance of causeway shall be measured in linear metres.

### 1910.5 Rate

The Contract unit rate for maintenance of causeway shall be payment in full compensation for:

- i) supplying of cement, sand, aggregates and all operations to repair the causeway surface and casting and installation of guide posts;
- ii) removal of debris and boulders etc.
- iii) all the labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1911 MAINTENANCE OF ROAD SIGNS

### 1911.1 Scope

The work shall consist of cleaning and repainting of Mandatory/Regulatory, Cautionary/ Warning, Informatory signs, bridge and culvert name plates as well as replacement of damaged or missing signs, as directed by the Engineer.

### 1911.2 Materials

The material for the repair/fabrication of signs shall be as per IRC:67.

### 1911.3 Repair Procedure and Maintenance

**1911.3.1** Over time, signs become faded and their retro-reflective properties diminish. This reduces both conspicuity and legibility, by day and by night. Excessively discoloured or faded signs (e.g. white backgrounds which have become grey or brown, or red borders faded to pink) and signs, where the legend or graphic is peeling cannot be fully effective, need to be replaced by signs conforming to the Specifications as per IRC:67 or as specified in the contract.

**1911.3.2** Signs along with the posts shall be maintained in proper position, and kept clean and legible at all times. Signs should be cleaned with soap water and damp cloth at intervals appropriate to the site conditions. Signs at locations where they are subject to heavy soiling from passing traffic, or algae growth (a common problem with signs beneath tree canopies) will need more frequent cleaning.

**1911.3.3** A reference number along with the month and year of installation should be placed on the back of a sign in a contrasting colour or by stamping in characters not exceeding 50 mm in height.

**1911.3.4** All signs shall be inspected every month both in day and night times. All signs shall be replaced at the end of the warranty period provided for the retro-reflective sheeting used on the sign. Damaged signs shall be replaced immediately by signs conforming to the Specifications as per IRC:67 or as specified in the contract.

**1911.3.5** Painting of the signs and posts by approved paints shall be undertaken after every two years or as specified in the contract or as directed by the Engineer.

**1911.3.6** Clearing of weeds, shrubbery, mud, etc. or any other obstructions obstructing the visibility of signs are to be done as directed by the Engineer.

### 1911.4 Measurements for Payment

The maintenance of regulatory/mandatory and cautionary/warning sign shall be measured in numbers for identical category of signs and informatory/direction signs including number plates for culverts and bridges shall be measured in square meters.

The replacement of damaged signs shall be measured separately.

### 1911.5 Rate

The Contract unit rate for maintenance of a road sign including culvert and bridge name plates shall be payment in full compensation for:

i) replacement of faded/damaged signs

ii) cleaning of road sign and post/posts with soap water and damp cloth;

iii) painting (where applicable) of road signs with approved paint and road sign post/posts painted with approved paint with alternate black and white horizontal stripes each not less than 100 mm wide;

iv) removal of weeds, shrubbery, mud, etc. obstructing the visibility of road signs;

v) repair of damaged signs or post and refixing of tilted signs;

vi) all labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1912 MAINTENANCE OF GUARD-RAILS AND PARAPET RAILS

### 1912.1 Scope

The work shall consist of prompt repair of damaged guard/parapet rails, cleaning and repainting regularly as directed by the Engineer.

### 1912.2 Material

The material for repair and repainting shall be as per Section 1700 of these Specifications.

### 1912.3 Repair Procedure

Guard-rails are provided to prevent vehicles from running over high embankment and parapet rails on bridges to safeguard pedestrians and vehicles. They shall be repaired promptly if damaged and kept clean and repainted regularly so as to maintain their visibility at all times.

### 1912.4 Measurements for payment

The repair of guard-rail, parapet-rail and their maintenance by cleaning and repainting shall be paid by the linear metres.

### 1912.5 Rate

The Contract unit rate for repair/maintenance of Guard-rail and Parapet-rail shall be payment in full compensation for:

i) repair of Guard-rail and Parapet-rail to their original condition;

ii) cleaning of Guard-rail and Parapet-rail with damp cloth and repainting, if required;

iii) all labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1913 KILOMETRE, HECTOMETRE STONES

### 1913.1 Scope

The work shall consist of refixing of tilted stones, repairing with cement mortar, cleaning with damp cloth, repainting and lettering on 200 m, kilometre and 5th kilometre stones, as directed by the Engineer.

### 1913.2 Material

The material for repair of 200 m and kilometre stones shall be as per Section 1700 of these Specifications. Repainting and lettering on stones shall be as per guidelines indicated in IRC:8 and IRC:26.

### 1913.3 Repair Procedure

The 200 m and kilometre stones shall be maintained in proper position and kept clean and legible at all times. Damaged as well as tilted stones shall be refixed or repaired/replaced immediately. Special care shall be taken to see that weeds, shrubbery, mud, etc. are not allowed to obscure any 200 m or kilometre stone.

### 1913.4 Measurements for Payment

The measurement shall be in numbers of 200 m, kilometre and 5th kilometre stones cleaned, repaired and repainted.

### 1913.5 Rate

The Contract unit rate for maintenance of 200 m, kilometer or 5th kilometer stone shall be payment in full compensation for:

i) cleaning;

ii) removal of weeds, shrubbery and mud, etc.;

iii) repair, repainting and lettering;

iv) all labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1914 MAINTENANCE OF ROAD DELINEATORS

### 1914.1 Scope

The work shall consist of cleaning, repainting of Roadway Indicators, Hazard Markers, Object Markers and keeping ground around the delineators clean by cutting and clearing grass/ bushes regularly, keeping the delineators visible as well as repair/replacement of damaged or missing delineators, as directed by the Engineer.

### 1914.2 Material

The material for repair/replacement of Roadway Indicators, Hazard Markers and Object Markers shall be as per IRC:79.

### 1914.3 Maintenance Procedure

Iron, steel, wooden or concrete posts shall be repainted regularly. To remove dirt, the reflective unit should be scrubbed clean with soap/detergent and water periodically, especially after the rains. The ground around the delineators should be kept clean by cutting grass, weeds and bushes regularly so that visibility of the delineators is not affected.

### 1914.4 Measurements for Payment

The measurement shall be in numbers of Roadway Indicators, Hazard Markers and Object Markers cleaned and repaired.

### 1914.5 Rate

The Contract unit rate for maintenance of delineators shall be payment in full compensation for :

i) cleaning;

ii) removal of weeds, shrubbery and mud, etc.;

iii) repainting of black and white stripes 150 mm wide on Roadway Indicator posts;

iv) all labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1915 CUTTING OF BRANCHES OF TREES, SHRUBS AND TRIMMING OF GRASS AND WEEDS

### 1915.1 Scope

The work shall consist of cutting of branches of trees, shrubs and trimming of grass and weeds from the Roadway or within the Road land as directed by the Engineer.

### 1915.2 Maintenance Procedure

All the branches of trees extending above the roadway shall be cut or trimmed so as to provide a clear height of 5 m above the road surface and shoulders. All shrubs, grass and weeds in the roadway or in the road land shall be trimmed and debris removed to a suitable location as directed by the Engineer to ensure unobstructed sight distance of adequate length.

### 1915.3 Measurements for Payment

The measurement for cutting of branches of trees and shrubs shall be in numbers and for trimming of grass and weeds in square metres.

### 1915.4 Rate

The Contract unit rate for cutting of branches of trees, shrubs and trimming of grass and weeds shall be payment in full compensation for:

i) cutting of branches of trees, shrubs and disposing of the wood and leaves, etc. to suitable locations as directed by the Engineer;

ii) trimming of grass and weeds manually or with electric cutters and disposing of the grass and debris to suitable locations as directed by the Engineer;

iii) all labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1916 WHITE WASHING OF PARAPET WALLS OF CD WORKS AND TREE TRUNKS

### 1916.1 Scope

The work shall consist of white washing of parapet walls of culverts, minor bridges and tree trunks, as directed by the Engineer.

### 1916.2 Maintenance Procedure

The parapet walls of culverts, minor bridges and tree trunks shall be cleaned of any scales, dirt or loose material and applied two coats of white wash using good unslaked lime.

### 1916.3 Measurements for Payment

The measurement for white washing of parapet walls of culverts, minor bridges and tree trunks shall be in square metres.

### 1916.4 Rate

The Contract unit rate for white washing of culverts, minor bridges and tree trunks shall be payment in full compensation for:

i) preparation of surface by cleaning, scraping scales, if any;

ii) two coats of white washing;

iii) all labour, material, tools, equipment and incidentals to complete the work in accordance with these Specifications.

## 1917 MAINTENANCE OF BIO-ENGINEERING WORKS

### 1917.1 Scope

The work shall cover maintenance of planted bio-engineering sites as directed by the Engineer. The work shall be carried out according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise and resources to ensure that these requirements are met.

### 1917.2 Site Protection

Because of the long time required for plants to become robust, the period of maintenance by the Contractor will normally be for 12 months.

The Contractor shall protect the planted site for the period specified. Protection is to include the prevention of damage to all manner of site works and plants by local people and domestic and wild animals. It also includes an active role in tending the plants and improving their growth.

### 1917.3 Maintenance Operations

The Contractor shall carry out weeding as required throughout the site. All weeds and other unwanted plants shall be cut just above the ground and the aerial parts will be used to make compost or mulch. Weeds must not be pulled out by the roots since this disturbs the ground surface.

Weeding should be carried out throughout the growing season. It must be undertaken with particular diligence at the end of the monsoon.

The Contractor shall carry out mulching as required throughout the site. All plants required under the bio-engineer specifications will be mulched using material prepared as described in the Specifications relating to Bio-engineering measures or the aerial parts of weeds cut on the site or brought from elsewhere for the purpose. The desired plants should be kept mulched at all times but special care must be taken in the spring when the soil moisture deficit is at its greatest.

The Contractor shall replace failed, damaged, diseased and weak plants using fresh, healthy plants of the same species, at the correct time of year for planting. The replacement operation will normally be carried out during the monsoon in the year following the first planting work. Vegetation structures will be enriched by the planting of additional cuttings as instructed by the Engineer.

In replanting and enrichment works, the Engineer may specify the use of different species. This will be done where failure or poor performance of plants may be attributed to poor stock or an incorrect initial choice of species.

Other maintenance operations shall be undertaken by the Contractor as per the instructions of the Engineer.

### 1917.4 Measurements for Payment

The maintenance of bio-engineering works shall be measured in square metres.

### 1917.5 Rate

The contract unit rate for maintenance shall include payment in full compensation for all labour, material and other resources for all items of works in accordance with these specifications.

## 2000

# MATERIALS FOR STRUCTURES

## 2001 GENERAL

Materials to be used in the work shall conform to the specifications mentioned on the drawings, the requirements laid down in this section and specifications for relevant items of work.

If any material, not covered in these Specifications, is required to be used in the work, it shall conform to relevant Indian Standards, if there are any, or to the requirements specified by the Engineer.

## 2002 SOURCES OF MATERIALS

The Contractor shall identify the sources of materials and notify the Engineer regarding the proposed sources prior to delivery.

Samples of materials from the source shall be tested in the presence of the Engineer for conformity to specifications. It shall also be ensured that the variation in test results of different samples, is within acceptable limits.

For manufactured items like cement, steel reinforcement and pre-stressing strands, the Contractor shall intimate the Engineer the details of the source, testing facilities available with the manufacturer and arrangements for transport and storage of material at site. If directed by the Engineer, the Contractor shall furnish samples and test results of recently received material. The Engineer, at his discretion, in case of doubt, may require the Contractor to test the materials in an independent laboratory approved by the Engineer and furnish test certificates. The cost of these tests shall be borne by the Contractor. The sampling and testing procedures shall be as laid down in the relevant Indian Standards and where they are not available, the same shall be carried out as per the directions of the Engineer. Only materials from sources approved by the Engineer shall be brought to the site. If the material from the approved source proves unacceptable at any time, the Contractor shall identify new sources of acceptable materials conforming to specifications.

## 2003 BRICKS

Burnt clay bricks shall conform to the requirements of IS:1077, except that the minimum compressive strength as per IS:3495 and as per Section 600, when tested flat, shall not be less than 8.4 MPa for individual bricks and mean strength not less than 10.5 MPa for a group of 5 specimens. They shall be free from cracks and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck. The size may be according to local practice with a tolerance of ± 5 percent.

Clay Flyash bricks shall conform to the requirements of IS:13757. The minimum compressive strength of any individual brick when tested as per IS:3495, shall not be less than the value specified in the drawings or 7 MPa whichever is more. The size shall be according to the local practice with tolerance of + 5 percent. The bricks shall be free from cracks, organic matter and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck.

Flyash shall conform to grade 1 or 2 of IS:3812. Bricks of 190 mm x 90 mm x 90 mm or 230 mm x 110 mm x 70 mm shall be preferred.

The bricks shall be subjected to the dimensional tolerance, water absorption, efflorescence and compressive tests before their use in the work and meet the requirements specified in IS:1077.

## 2004 STONES AND BLOCKS

### 2004.1 Stones

Stones shall be of the type specified. They shall be hard, sound, free from cracks, decay and weathering and shall be freshly quarried from an approved quarry. Stones with round surface shall not be used. Stone used shall conform to the requirements of IS:1597 Part (1).

The stones, when immersed in water for 24 hours, shall not absorb water of more than 5 percent of their dry weight when tested in accordance with IS:1124.

The length of stone shall not exceed three times its height and the width on the base shall not be greater than three-fourth of the thickness of the wall nor less than 150 mm.

### 2004.2 Blocks

Solid concrete blocks made of cement and suitable aggregates shall conform to relevant provisions of IS:2185 Part 1 in respect of dimension, mix, manufacturing, curing, drying and physical requirements. The minimum compressive strength of solid concrete blocks when tested as per IS:2185 Part 1 shall not be less than 10.5 MPa. Hollow light weight concrete blocks shall not be used in works.

The thickness of concrete block shall not be less than 200 mm and the width shall not be less than 200 mm. The density of concrete block shall not be less than 2.2 tonne/cum.

## 2005 CAST IRON

Cast iron shall conform to IS:210. The grade number of the material shall not be less than 14.

## 2006 CEMENT

**2006.1** Cement to be used shall be any of the following types with the prior approval of the Engineer.

- a) Ordinary Portland cement, 33 Grade, conforming to IS:269.
- b) Ordinary Portland cement, 43 Grade, conforming to IS:8112.
- c) Ordinary Portland cement, 53 Grade, conforming to IS:12269.
- d) Sulphate resisting Portland cement, conforming to IS:12330.
- e) Portland Pozzolana cement (fly ash based) conforming to IS:1489 (Part 1)

f) Portland slag cement conforming to IS:455

g) Rapid Hardening Portland cement, conforming to IS:8041.

h) Low heat Portland cement conforming to IS:12600

Cement of 33 grade conforming to IS:269 shall be used only after ensuring that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 450 kg/cum of concrete (excluding any mineral admixture).

Cements of 43 and 53 grades conforming to IS:8112 and IS:12269 respectively may be used provided the minimum cement content mentioned elsewhere from durability considerations, is not reduced.

Sulphate resisting cement conforming to IS:12330 shall be used when sodium sulphate and magnesium sulphate are present in large enough concentration to be aggressive to concrete. The recommended threshold values as per IS:456 are: sulphate concentration in excess of 0.2 percent in surrounding soil or 300 ppm (0.03 percent) in ground water. Cement conforming to IS:12330 shall be carefully selected from strength considerations to ensure that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 450 kg/cum (excluding any mineral admixture).

Alternatively, Portland slag cement conforming to IS:455 with slag content more than 50 percent can be used instead of sulphate resisting cement when the sulphate content in the surrounding soil is less than 1 percent or the sulphate content in the ground water is less than 2500 ppm.

Cement conforming to IS:8041 shall be used only for precast concrete products after specific approval of the Engineer.

Total chloride content shall be 0.1 percent by mass of cement for the cement to be used in structures other than prestressed concrete structures and 0.05 percent by mass of cement in prestressed concrete structures Also, total sulphur content calculated as sulphuric anhydride ($SO_3$) shall in no case exceed 3.5 percent.

Where chloride is encountered along with sulphates in soil or ground water, ordinary Portland cement with $C_3A$ content from 5 percent to 8 percent shall be preferably used in concrete, instead of sulphate resisting cement.

Manufacturer's test certificate shall be submitted to the Engineer by the contractor for every consignment of cement. The certificate shall cover all the tests for chemical requirements, physical requirements and chloride content as per relevant codes as applicable.

Independent tests of samples drawn from the consignment, shall be carried out at the site laboratory or in an independent laboratory approved by the Engineer, immediately after delivery. The following properties shall be tested:

i) Compressive strength.

ii) Setting time.

The cost of the tests shall be borne by the Contractor.

Cement in bags in local storage for more than 3 months after completion of tests, may be re-tested for compressive strength and setting times (initial and final) before use and may be rejected if it fails to conform to any of the requirements.

Lot size for independent testing of cement at site shall be the quantity received at site on any day, subject to a maximum of 500 tonnes.

### 2006.2 Lime

Lime when used as a part of composite mortar (Cement-lime mortar) shall conform to the specifications of type A and B of IS:712. Use of Quick lime shall not be permitted.

## 2007 CONCRETE ADMIXTURES

### 2007.1 General

Admixtures may be added to the concrete before or during mixing with a view to modifying one or more of the properties of concrete in the plastic or hardened state.

### 2007.2 Mineral Admixtures

Any of the following mineral admixtures may be used as part replacement of Portland Cement with the approval of the Engineer.

Fly ash: conforming to IS:3812-3.

Granulated slag: Ground granulated slag obtained by griding granulated slag conforming to IS:12089.

Silica fume: Silica fume is very fine, non- crystalline $SiO_2$ , obtained as a by-product of Silicon and Ferro – Silicon alloy industries and shall conform to IS:15388.

### 2007.3 Chemical Admixtures

#### 2007.3.1 *Information required from the manufacturer*

Chemical admixtures are proprietary items of manufacture and shall be obtained only from established manufacturers with proven track record, quality assurance and full fledged laboratory facilities for the manufacture and testing of concrete.

The contractor shall provide the following information concerning each admixture, after obtaining the same from the manufacturer:

a) Normal dosage and detrimental effects, if any, of under dosage and over dosage.

b) The chemical names of the main ingredients.

c) The chloride content, if any, expressed as a percentage by weight of the admixture.

d) Values of dry material content, ash content and relative density which can be used for Uniformity Tests.

e) Whether it leads to the entrainment of air when used as per the manufacturer's recommended dosage, and if so to what extent.

f) Confirmation regarding its compatibility with type of cement.

g) Whether it increases the risk of corrosion of reinforcement or other embedments.

h) Whether it affects the durability of concrete adversely.

### 2007.3.2 *Physical and chemical requirements*

Admixtures shall conform to the requirements of IS:9103. In addition, the following conditions shall be satisfied.

a) "Plasticisers" and "Super-Plasticisers" shall meet the requirements indicated for "Water reducing Admixture".

b) Except where resistance to freezing and thawing and to disruptive action of deicing salts is required, the air content of freshly mixed concrete in accordance with the pressure method given in IS:1199, shall not be more than 2 percent higher than that of the corresponding control mix and in any case not more than 3 percent of the test mix.

c) The chloride content of the admixtures shall not exceed 0.2 percent when tested in accordance with IS:6925. In addition, the maximum permissible limit of chloride content of all the constituents as indicated in Section 800 of these Specifications shall also not be exceeded.

d) Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times.

The tests that shall be performed along with permissible variations are as follows:

i) Dry Material Content : within 3 percent and 5 percent of liquid and solid

ii) Ash content : within 1 percent of the value stated by the manufacturer.

iii) Relative Density (for liquid admixtures) : within 2 percent of the value stated by the manufacturer.

e) All tests relating to concrete admixtures shall be conducted periodically at an independent laboratory and the results compared with the data given by the manufacturer.

## 2008 COARSE AGGREGATES

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel, natural gravel or a suitable combination thereof or other approved inert material. They shall not contain pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the steel reinforcement. Coarse aggregates having positive alkali-silica reaction shall not be used. All coarse aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS:2386, Parts I to VIII.

The Contractor shall submit for the approval of the Engineer, the entire information indicated in Appendix-A of IS:383.

Maximum nominal size of coarse aggregate for various structural components in PCC, RCC or PSC, shall conform to Section 800 of these Specifications.

The maximum value for flakiness index for coarse aggregate shall not exceed 35 percent. The coarse aggregate shall satisfy the requirements of grading as given in **Table 2000.1**.

**Table 2000.1 Grading Requirements of Coarse Aggregates**

| IS Sieve Size | Percentage Passing for Graded Aggregate of Nominal Size | | |
|---|---|---|---|
| | 40 mm | 20 mm | 12.5 mm |
| 63 mm | — | — | — |
| 40 mm | 95 – 100 | 100 | — |
| 20 mm | 30 – 70 | 95 – 100 | 100 |
| 12.5 mm | — | — | 90 – 100 |
| 10 mm | 10 – 35 | 25 – 55 | 40 – 85 |
| 4.75 mm | 0 – 5 | 0 – 10 | 0 – 10 |

## 2009 FINE AGGREGATES

For masonry work, sand shall conform to the requirements of IS:2116.

Natural sand, crushed stone sand or crushed gravel sand or a suitable combination of natural sand, crushed stone or gravel, shall be used as fine aggregates in plain, reinforced and prestressed concrete works. The fine aggregates shall be dense, durable, clean and free from veins and adherent coating and other deleterious substances. They shall not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Fine aggregates having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS:2386, (Parts I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix-A of IS:383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

Fine aggregate for structural concrete shall conform to the following grading requirements:

**Table 2000.2 Grading Requirements of Fine Aggregates**

| IS Sieve Size | Percent Passing for | | |
|---|---|---|---|
| | Grading Zone I | Grading Zone II | Grading Zone III |
| 10 mm | 100 | 100 | 100 |
| 4.75 mm | 90-100 | 90-100 | 90-100 |
| 2.36 mm | 60-95 | 75-100 | 85-100 |
| 1.18 mm | 30-70 | 55-90 | 75-100 |
| 600 micron | 15-34 | 35-59 | 60-79 |
| 300 micron | 5-20 | 8-30 | 12-40 |
| 150 micron | 0-10 | 0-10 | 0-10 |

***Note :*** When the grading falls outside the limits of any particular grading zone of sieves other than 600-micron IS Sieve by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. However for crushed stone sand, the permissible limit on 150-micron IS Sieve is increased to 20 percent. Reference shall be made to Clause: 4.3 of IS:383.

## 2010 WATER

Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.

In case of doubt regarding development of strength, the suitability of water proposed to be used for the production of concrete shall be ascertained by carrying out tests for the compressive strength of concrete and initial setting time of cement using the same water.

The sample of water taken for testing shall represent the water proposed to be used for concreting, taking into account seasonal variations, if any. The sample shall not receive any treatment before testing other than that being given to the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water.

Average 28 days compressive strength of at least three 150 mm concrete cubes prepared with water proposed to be used, shall not be less than 90 percent of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of IS:516.

The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes and shall not be more than 30 minutes from the initial setting time of control test block prepared with the same cement and distilled water.

The test blocks shall be prepared and tested in accordance with the requirements of IS:4031 (Part 5).

The pH value of water shall not be less than 6. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted.

As a guide, the following concentrations represent the maximum permissible values:

a) To neutralize 100 ml sample of water, using phenolphthalein as an indicator, it should not require more than 5 ml of 0.02 normal NaOH. For details of test refer IS:3025(Part 22).

b) To neutralize 100 ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 normal. $H_2SO_4$. For details of test refer IS:3025 (Part 23).

c) The Permissible limits for solids shall be as follows

| | Tested as Per | Permissible Limit max |
|---|---|---|
| Organic | IS:3025(Pt.18) | 200 mg/lit |
| Inorganic | IS:3025(Pt.18) | 3000 mg/lit |
| Sulphates ($SO_3$) | IS:3025(Pt.28) | 400 mg/lit |
| Chlorides (Cl) | IS:3025(Pt.32) | 2000 mg/lit for concrete work not containing embedded steel and 500 mg/lit for prestressed /reinforced concrete work |
| Suspended matter | IS:3025(Pt.17) | 2000 mg/lit |

All samples of water (including potable water) shall be tested and suitable measures taken, where necessary, to ensure conformity of the water to the requirements stated herein.

## 2011 STEEL

### 2011.1 Cast Steel

The use of cast steel shall be limited to bearings and other similar parts. Steel for castings shall conform to Grade 280-520N of IS:1030. In case where subsequent welding is unavoidable in the relevant cast steel components, the letter N at the end of the grade designation of the steel casting shall be replaced by letter W. 0.3 percent to 0.5 percent copper may be added to increase the corrosion resistance properties.

### 2011.2 Steel for Prestressing

The prestressing steel shall conform to any one of the following standards :

a) Plain hard drawn steel wire conforming to IS:1785 (Part I) and IS:1785 (Part II)

b) Cold drawn indented wire conforming to IS:6003

c) High tensile steel bar conforming to IS:2090

d) Uncoated stress relieved strands conforming to IS:6006

e) Uncoated stress relieved low relaxation seven ply strand for prestressed concrete conforming to IS:14268

Data in respect of modulus of elasticity, relaxation loss at 1000 hours, minimum ultimate tensile strength, stress strain curve etc. shall be obtained from the manufacturer. Pre-stressing steel shall be subjected to acceptance tests prior to actual use in the works.

### 2011.3 Reinforcement/Untensioned Steel

### 2011.3.1 *Reinforcing bars*

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, the reinforcement/untensioned steel as the case may be shall consist of the following grades of reinforcing bars.

**Table 2000.3 Grades of Reinforcing Bars**

| Grade Designation | Bar Type Conforming to Governing IS Specifications | Characteristic Strength fy MPa | Elastic Modulus GP |
|---|---|---|---|
| Fe 240 | IS:432 Part I Mild Steel | 240 | 200 |
| Fe 415 | IS:1786 High Strength Deformed steel bars | 415 | 200 |
| Fe 500 or Fe 500D | IS:1786 High Strength Deformed steel bars | 500 | 200 |
| Fe 550 or Fe 550D | IS:1786 High Strength Deformed steel bars | 550 | 200 |

***Notes :***

i) Wire fabrics conforming to IS:1566 can also be used as reinforcing steel.

ii) Other grades of bars conforming to IS:432 and IS:1786 shall not be permitted.

iii) For seismic zones III, IV & V, HYSD steel bars having minimum elongation of 14.5 percent and conforming to other requirements of IS:1786 shall be used

All steel shall be procured from original producers who manufacture billets directly from the iron ores and roll the billets to make steel conforming to IS:1786. No rerolled steel shall be incorporated in the works. However in case the original producers give certificate that they are unable to supply the steel within the stipulated time period or that they are not producing the required diameter bars, the Engineer may allow the procurement of steel from other suppliers provided that the reinforcement is manufactured from the billets procured from the original producers. In such cases, the manufacturer's certificate alone shall not be considered as sufficient and the steel shall be got tested by the Engineer in the NABL accredited laboratories as a third party check to comply with IS:1786 requirements.

Only new steel shall be delivered to the site. Every bar shall be inspected before assembling on the work and defective, brittle or burnt bar shall be discarded. Bars with cracked ends shall be discarded.

For the steel procured from original producers also the Engineer/Employer may carry out occasional checks on materials through third party as mentioned above, for confirming the test results shown in the certificates, in case of any doubt regarding the quality of steel supplied.

For the steel procured from original producers also the Engineer/Employer may carry out occasional checks on materials through third party as mentioned above, for confirming the test results shown in the certificates, in case of any doubt regarding the quality of steel supplied.

## 2012 TIMBER

The timber used for structural purposes shall conform to IS:883.

## 2013 REINFORCED AND PRESTRESSED CONCRETE PIPES

Reinforced concrete pipes for highway structures shall be of NP4 type conforming to the requirements of IS:458. Prestressed concrete pipes (NP4) conforming to IS:784 can also be used depending on the requirement.

## 2014 STORAGE OF MATERIALS

### 2014.1 General

All materials shall be stored at proper places so as to prevent their deterioration, intrusion of foreign matter and ensure their satisfactory quality and fitness for the work. The storage space must also permit easy inspection, removal and re-storage of the materials. All such materials, even though stored in approved godowns/places, must be subjected to acceptance test prior to their immediate use.

### 2014.2 Bricks

Bricks shall not be dumped at site, but shall be stacked in regular tiers as they are unloaded, to minimize breakage and defacement. Bricks selected for use in different situations shall be stacked separately. Sufficient supply of bricks as required for the works, shall be available at site at any time.

### 2014.3 Aggregates

Aggregate stockpiles may be made on ground that is hard, well drained and devoid of vegetation.

Coarse aggregates, unless otherwise agreed by the Engineer in writing, shall be delivered to the site in separate sizes (2 sizes when nominal size is 25 mm or less and 3 sizes when the nominal size is 32 mm or more). In case of aggregates placed directly on the ground, the material in the stock pile only up to a level of 30 cm above the ground level shall be taken out and used initially. Remaining material shall be permitted to be used in the final stages of work only after it has been fully cleaned.

### 2014.4 Cement

Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water-tight sheds and shall be stacked to a height of not more than eight bags. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirement at site. The containers shall be cleaned at least once every 3 months.

Cement shall be used in the sequence in which it is delivered at site. Each consignment shall be stored separately so that it may be readily identified and inspected. Any consignment or part of a consignment of cement which has deteriorated in any way during storage, shall not be used in the works and shall be removed from the site by the Contractor at his own cost.

The Contractor shall prepare and maintain proper records at site in respect of delivery, handling, storage and use of cement and these records shall be available for inspection by the Engineer at all times.

The Contractor shall submit a monthly return to the Engineer showing the quantities of cement received and issued during the month and in stock at the end of the month.

#### 2014.4.1 *Lime*

Lime shall be stored in weatherproof sheds. Lime which has been damaged by rain, moisture or air slaking shall not be used in the works. Hydrated lime shall be stored in the same manner as cement and period of storage shall not be more than one month.

### 2014.5 Reinforcement/Untensioned Steel

The reinforcement bars, shall be stored above the surface of the ground upon platforms, skids or other supports, and shall be protected from mechanical injury and from deterioration by exposure.

### 2014.6 Prestressing Materials

All prestressing steel, sheathing, anchorages and sleeves or couplers shall be protected during transportation, handling and storage. The prestressing steel, sheathing and other accessories shall be stored under cover from rain or damp ground and protected from the ambient atmosphere if it is likely to be aggressive. Period of storage at site must be kept to the absolute minimum.

a) **Tendons :** Wires, strands and bars from which tendons are to be fabricated shall be stored about 300 mm above the ground in a suitably covered and closed space so as to avoid direct climatic influences and to protect them from splashes from any other materials and from the cutting operation of an oxy-acetylene torch or arc welding process in the vicinity. Under no circumstances shall tendon material be subjected to any welding operation or on site heat treatment or metallic coating such as galvanizing. Storage facilities and the procedures for transporting material into or out of the store, shall be such that the material does not become kinked or notched. Wires or strands shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, for wires above 5 mm dia, coils of about 3 m dia without breaks or joints shall be obtained from manufacturer. Protective wrapping for tendons shall be chemically neutral. All prestressing steel must be provided with temporary protection during storage.

b) **Anchorage Components :** The handling and storing procedures shall maintain the anchorage components in a condition in which they can subsequently perform their function to an adequate degree. Components shall be handled and stored so that mechanical damage and detrimental corrosion are prevented. The corrosion of the gripping and securing system shall be prevented. The use of correctly formulated oils and greases or of other corrosion preventing material, shall be guaranteed by the producer to be non-aggressive and non-degrading.

Prestressing steel which shall be absolutely clean and without any signs of rust, shall be stored in a closed store having single door with double locking arrangements and no windows. The air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Engineer, so as to eliminate the possibility of initial rusting of prestressing steel during storage. Instrument measuring the air humidity shall be installed inside the store. The prestressing steel shall be coated with water-soluble grease.

All prestressing steel shall be stored at least 300 mm above ground level and shall be invariably wrapped with a protective covering of tar paper or polythene or any other approved material.

The Contractor should ensure that prestressing steel is used within 3 months of its manufacture. He should chalk out his prestressing programme in such a manner as to avoid the possibility of initial corrosion before placing in position.

### 2014.7 Water

Water shall be stored in containers/tanks covered at top and cleaned at regular intervals in order to prevent intrusion of foreign matter or growth of organic matter. Use of water from shallow, muddy or marshy sources, shall not be permitted. The intake pipe shall be suitably enclosed to exclude silt, mud, grass and other solid materials and there shall be a minimum depth of 0.60 m of water below the intake at all times.

## 2015 TESTS AND STANDARDS OF ACCEPTANCE

All materials, even though stored in an approved manner shall be subjected to an acceptance test in accordance with the relevant IS specification prior to their immediate use.

Independent testing of cement for every consignment shall be done by the Contractor at site or in the laboratory approved by the Engineer before use. Any cement with lower quality than that shown in manufacturer's certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

### 2015.1 Testing and Approval of Material

The Contractor shall furnish test certificates from the manufacturer/supplier of materials along with each batch of material(s) delivered to site.

The Contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products used in the construction as per requirements of conditions of contract and the relevant specifications. The testing of all the materials shall be carried out by the Engineer for which the Contractor shall make all the necessary arrangements and bear the entire cost.

Test which cannot be carried out in the field laboratory have to be got done by the Contractor at his cost at any recognized laboratory/testing establishments approved by the Engineer.

### 2015.2 Sampling of Materials

Samples provided to the Engineer for inspection are to be in labelled boxes suitable for storage.

Samples required for testing and approval must be supplied well in advance by at least 48 hours or before the minimum period required for carrying out the relevant tests. Delay to works arising from the late submission of samples, will not be acceptable as a reason for delay in completion of the works.

If materials are brought from abroad, the cost of sampling/testing whether in India or abroad shall be borne by the Contractor.

### 2015.3 Rejection of Materials not Conforming to the Specifications

Any stack or batch of material(s) of which sample(s) does (do) not conform to the prescribed tests and quality shall be rejected by the Engineer and such materials shall be removed from site by the Contractor at his own cost. Such rejected materials shall not be made acceptable by any rectifications.

### 2015.4 Testing and Approval of Plant and Equipment

All plants and equipment used for preparing, testing and production of materials for incorporation into the permanent works, shall be in accordance with manufacturer's specifications and shall be got approved from the Engineer before use.

# 2100

# ENVIRONMENT AND SOCIAL SAFEGUARDS

## 2101 SCOPE

**2101.1** The Contractor shall take all precautions for safeguarding the environment during the course of the construction of the works. He shall abide by all laws and rules and regulations in force governing pollution and environment or wild life protection that are applicable in the area where the works are situated. He shall submit to the Engineer for approval an Environment Management Plan (EMP) for the project indicating the likely adverse impact on environment and the measures that he proposes to adopt for mitigating the adverse impact. The Contractor shall implement the approved Environment Management Plan for safeguarding the environment.

**2101.2** While preparing the Environment Management Plan, measures suggested for minimization of environment impacts, safety of road users and enhancement of community benefits as indicated in the NRRDA Environment Codes of Practice (ECoP) shall be taken into consideration. **Annexure–2100.1** gives, at a glance, the coverage of various ECoPs.

**2101.3** The Contractor shall be responsible for obtaining all necessary approvals and no objection certificates from the relevant authorities, etc. in accordance with the rules and regulations in force.

**2101.4** Any structural damage caused to the existing roads by the Contractor due to use of such roads by his construction equipment shall be made good at his cost.

## 2102 PERSON INCHARGE

The Contractor shall assign one of his senior personnel the responsibility of ensuring that the construction practices comply with the ECoPs under intimation to the Engineer.

## 2103 ENVIRONMENTAL CONCERNS DURING IMPLEMENTATION OF WORKS

**Annexure–2100.2** provides a summary of concerns and reference to ECoP guidelines that shall be addressed by the Contractor during various pre-construction and construction activities.

## 2104 HEALTH AND SAFETY OF WORKERS AND THE PUBLIC

The Contractor and his Sub-Contractor shall comply with the ECoP-14.0 for ensuring health and safety of workers and the public affected by the project. He shall bring awareness among the workers to undertake health and safety precautions, particularly regarding personal safety measures, storage and handling of materials, disposal of construction waste, etc.

## 2105 SOCIAL SAFEGUARDS

**2105.1** The Contractor and his sub-Contractor shall take all reasonable steps to abide with the social safeguards as per PMGSY Guidelines relating to Environmental and Social Management Framework for the project affected persons of nearby habitations/ villages. He shall take up the execution of work in such a manner as to avoid damage or disturbance to persons, properties, farmlands, crops, grazing lands, water sources and other local resources, etc.

**2105.2** Before taking up execution, necessary information, disclosure and consultation with PIU, Sarpanch/Village Council Head and other Panchayati Raj/Village Council members shall be made for construction procedures, time schedules, location of labour camp, arrangement of water for construction purpose and temporary impact to society during construction periods. Land required temporarily for labour camp, storage of material, machinery, site office, etc. would be obtained in consultation with the community with written permission of the landowners. For works in tribal areas, the Contractor and his workers should get accustomed with the local tribal customs and should take up the execution of the works in such a manner so as to avoid any confrontation with the sentiments of the community.

**2105.3** In labour camps, information should be displayed in the shape of posters and banners for the prevention of HIV/AIDS and other diseases like Malaria, Diarrhoea, TB, etc.

**2105.4** During the course of execution, if any direct or indirect damage to the public properties, crops, etc. has occurred, the same should be compensated by the Contractor, at the current market value, as agreed with the affected persons.

**2105.5** After the completion of work, the Contractor should remove all his equipment, machinery, surplus building materials, labour camps, debris, etc. from the site, and its surrounding agricultural/non-agricultural lands, side-walks, pathways, water channels, drains, side-drains, etc. Guidelines given in ECoP-3 and ECoP-10 shall be followed.

## 2106 PAYMENT FOR ENVIRONMENT AND SOCIAL SAFEGUARDS

All measures, precautions, arrangements to be taken by the Contractor towards ensuring proper environment and social safeguards in compliance to the requirements stated above shall be considered as incidental to the works and shall be the Contractor's responsibility and the item rates quoted by the Contractor shall be deemed to include the cost of environment and social safeguards incurred by him.

## Annexure–2100.1

(Refer Clause 2101.2)

## Environmental Codes of Practice and their Coverage

| ECoP | Title | Key Issues Addressed |
|---|---|---|
| ECoP 1.0 | Project Planning and Design | • Incorporation of environmental concerns in project preparation to avoid impacts in construction and operation stages.<br>• Avoidance of roads through sensitive areas as reserved forests/ sanctuaries/ wetlands, etc.<br>• Compliance with legal requirements.<br>• Devising enhancement measures into project design. |
| ECoP 2.0 | Site Preparation | • Relocation of utilities, common property resources and cultural properties.<br>• Avoidance of effect on roadside vegetation. |
| ECoP 3.0 | Construction Camps | • Avoidance of sensitive areas for location of construction camps.<br>• Infrastructure arrangements for workers and construction equipment. |
| ECoP 4.0 | Alternate Materials for Construction | • Use of fly ash as per MOEF Notification.<br>• Minimizing earth requirement. |
| ECoP 5.0 | Borrow Areas | • Avoidance of agriculture lands.<br>• Redevelopment of borrow areas. |
| ECoP 6.0 | Topsoil Salvage, Storage and Replacement | • Topsoil removal from areas temporarily/permanently used for construction.<br>• Storage of topsoil in stockpiles and protection from erosion.<br>• Reuse of topsoil at areas to be revegetated and in agriculture lands. |
| ECoP 7.0 | Quarry Management | • Redevelopment of quarries in case new quarries are set up for the project. |
| ECoP 8.0 | Water for Construction | • Extraction of water in water scarce areas with consent of community.<br>• Scheduling construction activities as per water availability. |
| ECoP 9.0 | Slope Stability and Erosion Control | • Slope stability along hill roads.<br>• Protection of land on hill side from stability loss due to cutting.<br>• Protection of lands on valley side from debris due to construction.<br>• Adequacy of drainage for erosion control. |
| ECoP 10.0 | Waste Management | • Reuse of material from cutting in hill roads.<br>• Safe disposal of wastes. |

| ECoP | Title | Key Issues Addressed |
|---|---|---|
| ECoP 11.0 | Water Bodies | • Avoidance from cutting due to alignment.<br>• Protection of embankment slopes in case of alignment on embankments.<br>• Rehabilitation of water body. |
| ECoP 12.0 | Drainage | • Conducting hydrological investigations during project preparation.<br>• Provision of longitudinal and cross drainage as per requirements.<br>• Proper location of drainage outfall. |
| ECoP 13.0 | Construction Plants and Equipment Management | • Compliance of construction plants and equipment with emission standards of Central Pollution Control Board.<br>• Maintenance of machinery and equipment to avoid pollution. |
| ECoP 14.0 | Public and Worker's Health and Safety | • Provision of Personal Protective Equipment to workers.<br>• Provision of basic necessities to workers.<br>• Public safety while travel along construction sites.<br>• Public safety during operation of the road. |
| ECoP 15.0 | Cultural Properties | • Avoidance of impacts due to project.<br>• Protection of precincts from impacts due to construction.<br>• Relocation in case impacts are unavoidable. |
| ECoP 16.0 | Tree Plantation | • Avoidance of impact on trees.<br>• Plantation of trees on roadside. |
| ECoP 17.0 | Managing Induced Development | • Restricting ribbon development at junctions and bus stops.<br>• Earmarking areas for commercial activities and other amenities. |
| ECoP 18.0 | Environmental Audit | • Monitoring of environmental and social parameters during project planning, construction and implementation. |
| ECoP 19.0 | Natural Habitats | • Identification of natural habitats.<br>• Management measures for roads passing through natural habitats.<br>• Structure of management plan. |
| ECoP 19A | Biodiversity | • Provisions to address biodiversity issues, in addition to provisions provided for protecting Natural habitats as per ECoP 19.0. |
| ECoP 20.0 | Consultation Framework | • Aspects for consultation.<br>• Stage wise consultations.<br>• Consultation schedule and responsibilities. |

## Annexure–2100.2

(Refer Clause 2103)

### Environmental Concerns during Project Implementation

| Sl. No. | Activity and Sub Activity | Impact/s | Measure/s | ECoP Applicable |
|---|---|---|---|---|
| **A. Pre-construction Activity** | | | | |
| A1.0 | Alignment marking | -Nil- | Coordination with Revenue Department | ECoP 1.0<br>EcoP 2.0 |
| A2.0 | Relocation of utilities | Impact on current usage | i) Identification of relocation site in advance | ECoP 2.0 |
| | | | ii) Scheduling the activity in consonance with the community usage pattern. | ECoP 2.0 |
| A3.0 | Tree felling | Compliance with Forest Act in case trees are on forest land | i) Prior clearance from Forest Department | EcoP 1.0 |
| | | Loss of canopy | ii) Tree plantation as per roadside plantation plan | ECoP 16.0 |
| A4.0 | Clearance of land | Effect on standing crops | i) As per project provisions | ECoP 2.0 |
| | | | ii) Scheduling of activity and coordination | ECoP 1.0 |
| | | Effect on cultural properties | iii) Modification of alignment or Relocation of the cultural properties | ECoP 15.0 |
| | | Effect on natural habitats | iv) Avoidance of natural habitats or preparation of Natural Habitat Management Plan | ECoP 19.0 |
| A5.0 | Diversion of forest land | Compliance with Forest Act | i) Activity scheduling to avoid delays, conformance to legal requirements | ECoP 1.0 |
| | | Effect on flora | ii) Precautionary measures during construction in forest areas | All ECoPs |
| | | Pollution from construction activities | iii) Precautions while operating equipment/machinery | ECoP 13.0 |
| A6.0 | Transfer of land ownership | Grievances from community | i) Addressal through Grievance Redressal Mechanisms & Consultations | ECoP 1.0<br>ECoP 20.0 |
| | | Effect on livelihood | ii) Provision of entitlements as per resettlement framework | ECoP 1.0 |
| A7.0 | Location of Storage Yards, labour camps, and construction sites | Pollution from construction camps, storage yards & labour camps | i) Location criteria to be adopted | ECoP 3.0<br>ECoP 20.0 |
| | | | ii) Obtain clearances from SPCB | ECoP 1.0 |
| | | Pressure on local infrastructure | iii) Infrastructure arrangements to be as per guidelines | ECoP 3.0 |

| Sl. No. | Activity and Sub Activity | Impact/s | Measure/s | ECoP Applicable |
|---|---|---|---|---|
| A8.0 | Procurement of equipments and machinery | Machinery likely to cause pollution at settlements and natural habitats | i) Machinery to be procured shall be in conformance with noise and emission standards of CPCB | ECoP 13.0<br>ECoP 19.0 |
| | | Safety concerns in machinery operation | ii) Safety equipment for workers | ECoP 14.0 |
| A9.0 | Identification and Selection of Material Sources | Conflict of uses in case of water | i) Consultations and arrangements at contractor-individual levels, documentation of agreement | ECoP 8.0<br>ECoP 20.0 |
| | | Borrowing causes depressed lands | ii) Consultations and arrangements at contractor-individual levels, documentation of agreement | ECoP 5.0 |
| | | Pollution due to material extraction from borrow and quarry areas to surrounding environment | iii) Precautionary measures during siting of borrow areas and quarry areas | ECoP 5.0<br>ECoP 7.0 |
| | | Disturbance to Natural Habitats | iv) Avoidance of location of material sources in Natural Habitats | ECoP 19.0 |
| A10.0 | Identification of designated locations of waste disposal | Pollution due to location close to settlements, water bodies & other sensitive areas | Site selection in conformance to criteria provided | ECoP 10.0 |
| A 11.0 | Information to community | | Keeping local community informed about the construction schedule | ECoP. 2.0 |
| **B. Construction Activities** | | | | |
| B1.0 | Site Clearance | | | |
| B1.1 | Clearing and Grubbing | Effect on roadside vegetation | i) Restricting movement of machinery/equipment over adjacent fields | ECoP 2.0<br>ECoP 13.0 |
| | | Debris generation creating unsightly conditions | ii) Disposal / storage of grubbing waste and possible reuse | ECoP 10.0 |
| B1.2 | Dismantling of existing culverts and structures, if any | Generation of Debris creating unsightly conditions | i) Disposal of waste and likely reuse | ECoP 10.0 |
| | | Flooding due to interception to drainage paths | ii) Provision of diversion channels and/or scheduling construction of culverts preferably in dry months | ECoP 12.0 |
| B2.0 | Planning Traffic diversions and Detours | Trampling of vegetation along traffic diversions | Activity scheduling, identification of alternative track | ECoP 14.0 |

| Sl. No. | Activity and Sub Activity | Impact/s | Measure/s | ECoP Applicable |
|---|---|---|---|---|
| B3.0 | Material Procurement | Loss of topsoil | i) Stripping & Storing topsoil | ECoP 6.0 |
| | | Formation of stagnant water pools due to borrowing/quarrying | ii) Restoration plan for borrow areas & quarry areas (new quarry) | ECoP 5.0<br>ECoP 7.0 |
| | | Illegal quarrying/sand mining | iii) Conformance of quarries selected to the SPCB requirements, including quarry rehabilitation plans | ECoP 7.0 |
| | | Uncontrolled blasting at quarries | iv) Controlled blasting to the extent required. Conformance to blasting rules as per the Indian Explosives Act | ECoP 7.0 |
| B4.0 | Transport of materials to site | Fugitive emissions from transport trucks | i) Covering of material with tarpaulin or use of covered box trucks during transport | ECoP 10.0 |
| | | Dust emissions from haul roads | ii) Haul road management | ECoP 13.0 |
| B5.0 | Materials handling | | | |
| B5.1 | Storage of materials | Contamination to water sources, leaching into ground water | Provision of impervious base to storage areas | ECoP 3.0 |
| B5.2 | Handling of earth | Dust rising and increase in particulate concentration in ambient air | Use of dust suppressants | ECoP 13.0 |
| B5.3 | Handling of fly ash | Increase of particulate concentration and contamination of nearby areas | Use of dust suppressants | ECoP 4.0 |
| B5.4 | Handling of granular material | Risk of injury to workers | Use of Personal Protective Equipment | ECoP 14.0 |
| B5.5 | Handling of bituminous materials | Leaching of materials, contamination of water sources | i) Provision of impervious base at bitumen storage areas | ECoP 10.0 |
| | | Air pollution | ii) Control of emissions from mixing | ECoP 13.0 |
| B5.6 | Handling of oil/ diesel | Contamination from accidental spills | i) Prevention of accidental spills, affecting cleaning immediately after spill | ECoP 13.0 |
| | | Pollution due to incomplete burning | ii) Ensure complete combustion of fuel through regular maintenance of equipment | ECoP 13.0 |

| Sl. No. | Activity and Sub Activity | Impact/s | Measure/s | | ECoP Applicable |
|---|---|---|---|---|---|
| B5.7 | Waste management | Littering of debris at construction site | i) | Waste to be disposed at disposal locations only/ utilized in pavement as capping layer/ in sub-base or base course | ECoP 10.0 |
| | | Contamination of surroundings due to runoff from construction site | ii) | Prevention of runoff from entering water bodies | ECoP 11.0 |
| B5.8 | Operation of construction equipments and machinery | Air & Noise pollution | i) | Conformance to Emission standards and norms | ECoP 13.0 |
| | | Operational safety of workers | ii) | Conformance to Safety concerns of the road users and workers in operation, first aid provision and mandatory provision of Personal Protective Equipment | ECoP 14.0 |
| B5.9 | Movement of Machinery | Trampling of vegetation | i) | Restriction of movement within ROW | ECoP 13.0 |
| | | Damage to flora & natural habitats | ii) | Minimizing impact on vegetation | ECoP 13.0<br>ECoP 19.0 |
| | | Damage to road side properties | iii) | Minimizing impacts on private and common properties, including religious structures | ECoP 13.0<br>ECoP 15.0 |
| B6.0 | Earthworks | | | | |
| B6.1 | Cutting | Uncontrolled blasting in case of rock cutting | i) | Controlled blasting to be made mandatory | ECoP 7.0 |
| | | Loss of topsoil | ii) | Preservation of topsoil for reuse | ECoP 6.0 |
| | | Waste generation | iii) | Safe disposal of waste & possible reuse | ECoP 10.0 |
| B6.2 | Embankment construction | Interruption to drainage | i) | Drainage channels to be provided with culverts in advance to embankment construction as far as possible | ECoP 12.0 |
| | | Dust Rising | ii) | Dust suppression with water | ECoP 13.0 |
| | | Excess water/material usage | iii) | Minimising height of embankment | ECoP 1.0 |
| | | | iv) | Scheduling embankment construction preferably in wet months, if possible | ECoP 1.0 |
| | | | v) | Compaction with vibratory rollers is suggested | ECoP 1.0 |

| Sl. No. | Activity and Sub Activity | Impact/s | Measure/s | | ECoP Applicable |
|---|---|---|---|---|---|
| | | Erosion causing impact on embankment/slope stability | vi) | Slope stabilization measures as seeding, mulching & bioengineering techniques | ECoP 9.0 |
| | | Formation of rills/gullies | vii) | Construction of temporary erosion control structures as per requirements | ECoP 9.0 |
| | | Contamination of water bodies/ water courses | viii) | Control measures as silt fencing, vegetative barriers etc | ECoP 9.0 |
| | | | ix) | Avoiding disposal of liquid wastes into natural water courses | ECoP 11.0 |
| B6.3 | Maintenance at construction camp | Collection of rainwater in construction camps | i) | Temporary drains during construction | ECoP 3.0 |
| | | Waste water from labour camps | ii) | Disposal of waste water into soak pits | ECoP 3.0 |
| | | Contamination of soil | iii) | Removal of oil/other chemical spills & wastes | ECoP 3.0 |
| B6.4 | Cutting embankments of surface water bodies | Impact on the drainage flows in and out of the water body | i) | Restoration of drainage channels | ECoP 11.0 |
| | | Embankment stability | ii) | Design of slopes of the water bodies, slope protection etc | ECoP 9.0 |
| B7.0 | Sub-Base & Base courses | | | | |
| B7.1 | Granular sub-base | Extensive extraction of quarry materials | Use of locally available materials (licensed quarry) Use of cut material | | ECoP 4.0/<br>ECoP 10.0 |
| B7.2 | Wet mix macadam | Extensive water requirement | i) | Scheduling the activity preferably in wet months | ECoP 1.0 |
| | | | ii) | Avoiding conflict of uses due to water extraction from construction | ECoP 8.0 |
| B7.3 | Shoulders treatment | Movement of Machinery for compaction | ii) | Restricting movement on adjacent lands | ECoP 13.0 |
| | Slope Protection | Slope stability | iii) | Bio-engineering practices | ECoP 9.0A |
| B8.0 | Culverts and Minor Bridge Works | Interruption to water flow | i) | Provision of diversion channels | ECoP 12.0 |
| | | Pollution of water channels during construction | ii) | Control of sediment runoff | ECoP 12.0 |
| | | Safety of Workers | iii) | Mandatory use of personal protective equipment | ECoP 14.0 |

| Sl. No. | Activity and Sub Activity | Impact/s | Measure/s | ECoP Applicable |
|---|---|---|---|---|
| B9.0 | Surfacing | | | |
| B9.1 | Bituminous surface | Worker's safety during handling of hot mix | i) Mandatory use of Personal Protective Equipment | ECoP 14.0 |
| | | Damage to vegetation (burning/ cutting) | ii) Avoiding use of wood as fuel for heating bitumen as far as possible | ECoP 13.0 |
| | | | iii) Hot mix plant location to be preferably on waste lands | ECoP 13.0 |
| | | Contamination due to bituminous wastes | iv) Reuse or land filling of bituminous wastes or use in subbase | ECoP 10.0 |
| | | Impacts on Air quality | v) Ensuring compliance of hotmix plants with the CPCB emission standards | ECoP 13.0 |
| B9.2 | Concrete surfacing for roads crossing built up areas | Contamination of surroundings due to concrete mixing | Mixing concrete at designated locations away from habitation and agriculture lands | ECoP 3.0 |
| B10.0 | Road furniture/ signage | | To be provided as per design | |
| B11.0 | Shoulder protection | Requires material extraction from quarries | i) Use locally available material (licensed quarry) | ECoP 4.0 |
| | | | ii) Ensure that all shoulders are clear of debris or construction materials | ECoP 13.0 |
| B12.0 | Enhancements | | To be included in DPR | ECoP 1.0<br>ECoP 20.0 |
| B13.0 | Monitoring environmental conditions | | To be as per the codes of environmental practice | ECoP 18.0 |
| **C. Post Construction Activities** | | | | |
| C1.0 | Clearing of construction camps | | | |
| C1.1 | Campsite restoration | Change of land use due to setting up of construction camp | i) Campsite to be restored to its original condition as per the rehabilitation plan | ECoP 3.0 |
| | | | ii) Restoration of top soil | ECoP 6.0 |

| Sl. No. | Activity and Sub Activity | Impact/s | Measure/s | ECoP Applicable |
|---|---|---|---|---|
| C1.2 | Dismantling of Camp site | Waste generation at the construction site | Disposal of waste at designated locations | ECoP 10.0 |
| C2.0 | Clearing of Water Channels, side drains and culverts | Generation of debris and silt | Removal of debris and disposal | ECoP 11.0<br>ECoP 12.0 |
| C3.0 | Rehabilitation of borrow areas | | Top soil restoration, re-vegetation | ECoP 5.0 |
| C4.0 | Clearing of encroachments | Loss of livelihood | Precautionary measures to avoid encroachments | ECoP 17.0 |
| C5.0 | Maintenance of vegetation | Loss of green cover | To ensure that there is no gap of time after handing over and proper maintenance of plants and other vegetation | ECoP 16.0/<br>ECoP 9.0A |

# APPENDICES

## Appendix-1

(Refer Clause 101)

## LIST OF IRC PUBLICATIONS REFERRED TO IN THE SPECIFICATIONS

| Number | Title |
|---|---|
| | **(A) INDIAN ROADS CONGRESS** |
| IRC:5-1998 | Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design (Seventh Revision) |
| IRC:8-1980 | Type Designs for Highway Kilometre Stones (Second Revision) |
| IRC:14-2004 | Recommended Practice for Open Graded Premix Carpets (Third Revision) |
| IRC:15-2011 | Standard Specification and Code of Practice for Construction of Concrete Roads (Fourth Revision) |
| IRC:16-2008 | Standard Specifications and Code of Practice for Prime and Tack Coat (Second Revision) |
| IRC:19-2005 | Standard Specification and Code of Practice for Water Bound Macadam (Third Revision) |
| IRC:25-1967 | Type Designs for Boundary Stones |
| IRC:26-1967 | Type Designs for 200–Metre Stones |
| IRC:27-2009 | Specifications for Bituminous Macadam (First Revision) |
| IRC:28-1967 | Tentative Specifications for the Construction of Stabilised Soil Roads with Soft Aggregate in Areas of Moderate and High Rainfall |
| IRC:35-1997 | Code of Practice for Road Markings (First Revision) |
| IRC:36-2010 | Recommended Practice for Construction of Earth Embankments and Sub-Grade for Road Works (First Revision) |
| IRC:38-1988 | Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision) |
| IRC:44-2008 | Tentative Guidelines for Cement Concrete Mix Design for Pavements (Second Revision) |
| IRC:56-2011 | Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control (First Revision) |
| IRC:57-2006 | Recommended Practice for Sealing of Joints in Concrete Pavements (First Revision) |
| IRC:67-2012 | Code of Practice for Road Signs (Third Revision) |
| IRC:75-1979 | Guidelines for the Design of High Embankments |

| | |
|---|---|
| IRC:76-1979 | Tentative Guidelines for Structural Strength Evaluation of Rigid Airfield Pavement |
| IRC:78-2014 | Standard Specifications and Code of Practice for Road Bridges, Section VII - Foundations & Sub-structure (Second Revision) |
| IRC:79-1981 | Recommended Practice for Road Delineators |
| IRC:81-1997 | Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique (First Revision) |
| IRC:82-1982 | Code of Practice for Maintenance of Bituminous Surfaces of Highways |
| IRC:83-1999(Part-I) | Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part I : Metallic Bearings (First Revision) |
| IRC:83-1999 (Part-II) | Standard Specifications and Code of Practice for Road Bridges, Section IX - Bearings, Part II: Elastomeric Bearings |
| IRC:83-2002 (Part-III) | Standard Specifications and Code of Practice for Road Bridges, Section IX - Bearings, Part III: POT, POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS |
| IRC:87-2011 | Guidelines for Formwork, False Work and Temporary Structures (First Revision) |
| IRC:89-1997 | Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision) |
| IRC:93-1985 | Guidelines on Design and Installation of Road Traffic Signals |
| IRC:110-2005 | Standards Specifications and Code of Practice for Design and Construction of Surface Dressing |
| IRC:111-2009 | Specifications for Dense Graded Bituminous Mixes |
| IRC:112-2011 | Code of Practice for Concrete Road Bridges |
| IRC:SP:16-2004 | Guidelines for Surface Evenness of Highway Pavements (First Revision) |
| IRC:SP:20-2002 | Rural Roads Manual |
| IRC:SP:34-1989 | General Guidelines About the Equipment for Bituminous Surface Dressing |
| IRC:SP:42-1994 | Guidelines on Road Drainage |
| IRC:SP:46-2013 | Guidelines for Design and Construction of Fibre Reinforced Concrete Pavements (First Revision) |
| IRC:SP:47-1998 | Guidelines on Quality Systems for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete) |

| | |
|---|---|
| IRC:SP:48-1998 | Hill Road Manual |
| IRC:SP:49-1998 | Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement |
| IRC:SP:53-2014 | Guidelines on Use of Modified Bitumen in Road Construction (Second Revision) |
| IRC:SP:55-2014 | Guidelines for Safety in Construction Zones |
| IRC:SP:57-2000 | Guidelines for Quality Systems for Road Construction |
| IRC:SP:62-2014 | Guidelines for the Design and Construction of Cement Concrete Pavement for Rural Roads |
| IRC:SP:63-2004 | Guidelines for the Use of Interlocking Concrete Block Pavement |
| IRC:SP:68-2005 | Guidelines for Construction of Roller Compacted Concrete Pavements |
| IRC:SP:72-2007 | Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads |
| IRC:SP:74-2007 | Guidelines for Repair and Rehabilitation of Steel Bridges |
| IRC:SP:76-2008 | Tentative Guidelines for Conventional, Thin and Ultra-Thin Whitetopping |
| IRC:SP:79-2008 | Tentative Specifications for Stone Matrix Asphalt |
| IRC:SP:80-2008 | Guidelines for Corrosion Prevention, Monitoring and Remedial Measures for Concrete Bridge Structures |
| IRC:SP:81-2008 | Tentative Specification for Slurry Seal and Microsurfacing |
| IRC:SP:82-2008 | Guidelines for Design of Causeways and Submersible Bridge |
| IRC:SP:83-2008 | Guidelines for Maintenance, Repairs & Rehabilitation of Cement Concrete Pavements |
| IRC:SP:89-2010 | Guidelines for Soil and Granular Material Stabilization Using Cement Lime and Fly Ash |
| IRC:SP:98-2013 | Guidelines for the Use of Waste Plastic in Hot Bituminous Mixes (Dry Process) in Wearing Courses |

## (B) MINISTRY OF RURAL DEVELOPMENT

Quality Assurance Handbook - Volume I & II May, 2007 (issued by NRRDA)

## (C) MINISTRY OF ROAD TRANSPORT AND HIGHWAYS

Specifications for Road and Bridge Works (Fifth Revision) - 2013

## Appendix-2

(Refer Clause 103)

## LIST OF INDIAN AND FOREIGN STANDARDS REFERRED TO IN THE SPECIFICATIONS

| Number | Title |
|---|---|
| | **(A) INDIAN STANDARDS** |
| IS:73-1992 | Paving Bitumen Specification (Second Revision) |
| IS:77-1976 | Specification for Linseed Oil;, Boiled, for Paints(Second Revision) |
| IS:102-1962 | Ready Mixed Paint, Brushing, Red Lead, Non Setting, Primming |
| IS:104-1979 | Ready Mixed Paint, Brushing, Zinc Chrome, Primming (Second Revision) |
| IS:123-1962 | Specification for Ready Mixed Paint, Brushing, Finishing, Semi-Gloss. For General Purposes, to Indian Standard Colours (Revised Revision) |
| IS:164-1981 | Specification for Ready Mixed Paints for road marking (First Revision) |
| IS:217-1988 | Specification for Cutback Bitumen (Second Revision) |
| IS:226-1975 | Structural Steel (Standard Quality) (Fifth Revision) |
| IS:269-1989 | Specification for 33 Grade Ordinary Portland Cement (Fourth Revision) |
| IS:278-2009 | Galvanized Steel Barbed Wire for Fencing-Specification |
| IS:280-2006 | Mild Steel Wire for General Engineering Purposes (Fourth Revision) |
| IS:345-1952 | Wood Filter Transparent Liquid |
| IS:356-1991 | Ester Gum (Second Revision) |
| IS:383-1970 | Specification for Coarse and Fine aggregates from Natural Sources for Concrete (Second Revision) |
| IS:460-1985 (Part 3) | Specification for Test Sieves: Part III Methods of Examination of Apertures of Test Sieves (Third Revision) |
| IS:503-1963 | Alloy Austenitic Manganese Steel Castings |
| IS:516-1959 | Methods of Test for Strength of Concrete |
| IS:712-1984 | Specifications for Building Limes(Third Revision) |
| IS:736-1986 | Wrought Aluminum and Aluminum Alloys, Plates for General Engineering Purposes (Fourth Revision) |
| IS:783-1985 | Code of Practice for Laying of Concrete Pipes (First Revision) |
| IS:784-2001 | Prestressed Concrete Pipes (Including Fittings) – Specifications (Second Revision) |

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| IS:814-2004 | Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel (Fifth Revision) |
| IS:816-1969 | Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel (First Revision) |
| IS:817-1966 | Code of Practice for Training and Testing of Metal Arc Welders (Revised Revision) |
| IS:822-1970 | Code of Procedure for Inspection of Welds |
| IS:877-1989 | Methods of Sampling and Test for Activated Carbons, Powered and Granular (Second Revision) |
| IS:919-1993(Part-1) | ISO Systems of Limits and Fits Part 1 Bases of Tolerance, Deviation and Fits (Second Revision) |
| IS:919-1993(Part-2) | ISO Systems of Limits and Fits Part 2 Tables of Standard Tolerance Grades and Limit Deviations for Holes and Shafts (First Revision) |
| IS:961-1975 | Structural Steel (High Tensile) (Second Revision) |
| IS:1077-1992 | Common Burnt Clay Building Bricks (Fifth Revision) |
| IS:1079-1994 | Hot Rolled Carbon Steel Sheets and Strips-Specifications (Sixth Revision) |
| IS:1124-1974 | Method of Test for Water Absorption, Apparent Specific Gravity and Porosity of Natural Building Stones (First Revision) |
| IS:1129-1972 | Recommendation for Dressing of Natural Building Stones (First Revision) |
| IS:1148-1982 | Hot Rolled Rivet Bars(upto 40 mm dia) for Structural Purposes (Third Revision) |
| IS:1149-1982 | Hot Tensile Steel Rivet Bars for Structural Purposes (Third Revision) |
| IS:1182-1983 | Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates(Second Revision) |
| IS:1199-1959 | Method of Sampling and Analysis of Concrete |
| IS:1203-1978 | Determination of Penetration |
| IS:1205-1978 | Determination of Softening Point |
| IS:1212-1978 | Determination of Loss on Heating |
| IS:1216-1978 | Determination of Solubility in Carbon Disulphide Trichlorothylene |
| IS:1217-1978 | Determination of Mineral Matter |
| IS:1239:(Part 1)-1990 | Steel Tubes, Tubulars and Other Wrought Steel Fittings-Specification: Part 1 Steel Tubes |
| IS:1363-2002 (Part 1,2 & 3) | Hexagonal Head Bolts, Screws and Nuts of Product Grade 'C' |

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| IS:1364-2002 (Part 1,2 &3) | Hexagonal Head Bolts, Screws and Nuts of Product Grade 'A' & 'B' |
| IS:1365-2005 | Slotted Countersunk, Flat Head Screws (Common Head Style)-Product Grade A (Fourth Revision) |
| IS:1367-1997 | Technical supply conditions for Threaded Steel Fasteners |
| IS:1393-1961 | Code of Practice for Training and Testing of Oxy Acetylene Welders |
| IS:1477-1971 (Parts 1 & 2) | Code of Practice for Painting of Ferrous Metals in Buildings |
| IS:1489-1991 | Specification for Portland pozzolana Cement(Third Revision) |
| (Part 1) | Flyash Based (Third Revision) |
| (Part 2) | Calcined Clay Based (Third Revision) |
| IS:1498-1970 | Classification and Identification of Soils for General Engineering Purposes (First Revision) |
| IS:1514-1990 | Methods of Sampling and Test for Quick Lime and Hydrated Lime (First Revision) |
| IS:1597-1992 (Part 1) | Construction of Stone Masonry - Code of Practice - Part 1 - Rubble Stone Masonry (First Revision) |
| IS:1732-1989 | Dimensions for Round and Square Steel Bars for Structural and General Engineering Purposes (Second Revision) |
| IS:1745-1978 | Specification for Petroleum Hydrocarbon Solvent (Second Revision) |
| IS:1785-1983(Part-1) | Specification for Plain, Hard Drawn Steel Wire for Prestressed Concrete:Part 1 Cold Drawn Stress Relieved Wire (Second Revision) |
| IS:1785-1983(Part-II) | Specification for Plain, Hard Drawn Steel Wire for Prestressed Concrete:Part 2 As Drawn Wire (First Revision) |
| IS:1786-1985 | High Strength Deformed Steel Bars and Wires for Concrete Reinforcement (Third Revision) |
| IS:1834-1984 | Specification for Hot Applied Sealing Compounds for Joints in Concrete (First Revision) |
| IS:1838-1983(Part 1) | Specification for Preformed Filler for Expansion Joint in Concrete Pavement and Structures (Non-Extruding and Resilient Type):Part 1 Bitumen Impregnated Fibre (First Revision) |
| IS:1838-1984(Part 2) | Specification for Preformed Filler for Expansion Joint in Concrete Pavement and Structures (Non-Extruding and Resilient Type):Part 2 CNSL Aldehyde Resin and Coconut Pith |
| IS:1852-1985 | Rolling and Cutting Tolerances for Hot Rolled Steel Products (Fourth Revision) |

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| IS:1875-1992 | Carbon Steel Billets, Blooms, Slabs and Bars for Forgings (Fifth Revision) |
| IS:1888-1982 | Method of Load Test on Soils (Second Revision) |
| IS:1892-1979 | Code of Practice for Sub Surface Investigation for Foundations (First Revision) |
| IS:1966-2003 | Laboratory Glassware-Straight Bore Glass Stopcocks for General Purposes (First Revision) |
| IS:1977-1996 | Low Tensile Structural Steels –Specifications (Third Revision) |
| IS:1995-1984 | Overall Internal Heights for Lathe Tool Posts (First Revision) |
| IS:2004-1991 | Carbon Steel Forgings for General Engineering Purposes (Third Revision) |
| IS:2016-1967 | Specification for Plain Washers (First Revision) |
| IS:2062-2006 | Hot Rolled Low, Medium and High Tensile Structural Steel (Sixth Revision) |
| IS:2090-1983 | Specifications for High Tensile Steel Bars used in Prestressed Concrete (First Revision) |
| IS:2116-1980 | Specification for Sand for Masonry Mortars (First Revision) |
| IS:2131-1981 | Method for Standard Penetration Test for Soils (First Revision) |
| IS:2132-1986 | Code of Practice for Thin Walled Tube Sampling of Soils (Second Revision) |
| IS:2185-2005(Part-1) | Concrete Masonry Units-Specification: Part 1-Hollow and Soild Concrete Blocks |
| IS:2250-1981 | Code of Practice for Preparation and Use of Masonry Mortars (First Revision) |
| IS:2269-2006 | Hexagon Socket Head Cap Screws (Fifth Revision) |
| IS:2339-1963 | Aluminum Paint for General Purposes in Dual Container |
| IS:2386-1963 | Methods of Test for Aggregates for Concrete |
| (Part 1) | Particle size and shape |
| (Part 2) | Estimation of Deleterious Materials and Organic Impurities |
| (Part 3) | Specific Gravity, Density, Voids, Absorption and Bulking |
| (Part 4) | Mechanical Properties |
| (Part 5) | Soundness |
| (Part 6) | Measuring Mortar Making Properties of Fine Aggregates |
| (Part 7) | Alkali Aggregate Reactivity Test |
| (Part 8) | Petrographic examination |

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| IS:2502-1963 | Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement |
| IS:2506-1985 | General Requirements for Screed Board Concrete Vibrators (First Revision) |
| IS:2514-1963 | Specification for Concrete Vibrating Tables |
| IS:2720 | Methods of Test for Soils |
| (Part 1)-1983 | Preparation of Dry Soil Samples for Various Tests (Second Revision) |
| (Part 2)-1973 | Determination of Water Content (Second Revision) |
| (Part 4)-1985 | Grain Size Analysis (Second Revision) |
| (Part 5)-1985 | Determination of Liquid and Plastic Limits (Second Revision) |
| (Part 8)-1983 | Determination of Water Content Dry Density Relation using Heavy Compaction (Second Revision) |
| (Part 16)-1987 | Laboratory Determination of CBR |
| (Part 27)-1977 | Determination of Total Soluble Sulphates(First Revision) |
| (Part 28)-1974 | Determination of Dry Density of Soils in-place by the Sand Replacement Method (First Revision) |
| (Part-37)-1976 | Determination of Sand Equivalent Values of Soils and Fine Aggregates |
| (Part 40)-1977 | Determination of Free Swell Index of Soils |
| IS:2751-1979 | Code of Practice for Welding of Mild Steel Plain and Deformed Bars for Reinforced Concrete Construction (First Revision) |
| IS:2911 (Part-1) (Sec-3) -1979 | Code of Practice for Design and Construction of Pile Foundations Concrete Piles, Section 3 Driven Precast Concrete |
| IS: 2925-1984 | Specification for Industrial Safety Helmets (Second Revision) |
| IS:3025:(Part 17)-1984 | Methods of Sampling and Test (Physical And Chemical) for Water and Waste water: Part 17 Non-Filterable Residue (Total Suspected Solids) (First Revision) |
| IS:3025:(Part 18)-1984 | Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water- Part 18 Volatile and Fixed Residue (Total Filterable and Non-Filterable) (First Revision) |
| IS:3025:(Part 22)-1986 | Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water- Part 22 : Acidity (First Revision) |
| IS:3025:(Part 23)-1986 | Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water- Part 23: Alkalinity (First Revision) |
| IS:3025:(Part 28)-1984 | Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water- Part 28: Sulphite (First Revision) |
| IS:3025 (Part 32)-1988 | Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water- Part 32: Chloride (First Revision) |
| IS:3073-1967 | Assessment of Surface Roughness |

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| IS:3138-1966 | Specifications for Hexagonal Bolts and Nuts |
| IS:3400 (Part 3)-2004 | Methods of Test for Vulcanized Rubbers: Part 3 Abrasion Resistance Using a Rotating Cylindrical Drum Device (First Revision) |
| IS:3400 (Part 2)-2004 | Methods of Test for Vulcanized Rubbers: Part 2 Rubber Vulcanized or Thermoplastic-Determination of Hardness (Hardness between 10 IRHD and 100 IRHD) (Third Revision) |
| IS:3400 (Part 4)-2004 | Methods of Test for Vulcanized Rubbers: Part 4 Accelerated Ageing (Second Revision) |
| IS:3400 (Part 10)-2004 | Methods of Test for Vulcanized Rubbers: Part 10 Compression Set at Constant Strain (First Revision) |
| IS:3400 (Part 14)-1984 | Methods of Test for Vulcanized Rubbers: Part 14 Adhesion of Rubber to Metal (First Revision) |
| IS:3400 (Part 20)-2004 | Methods of Test for Vulcanized Rubbers: Part 20 Resistance to Ozone Cracking-Static Strain Test (First Revision) |
| IS:3589-2001 | Steel Pipes for Water and Sewage (168.3 to 2540 mm Outside Diameter)-Specification (Third Revision) |
| IS:3613-1974 | Acceptance Tests for Wire Flux Combination for Submerged Arc Welding (First Revision) |
| IS:3658-1999 | Code of Practice for Liquid Penetrant Flaw Detection (Second Revision) |
| IS:3764-1992 | Code of Safety for Excavation Work (First Revision) |
| IS:3784-1994 | Textiles –Cloth, Cotton Khadi Bleached for General Purposes-Specification (First Revision) |
| IS:3812:1981 | Specification for Fly Ash for Use as Pozzolana and Admixture (First Revision) |
| IS:4031:(Part 5)-1988 | Methods of Physical Tests for Hydraulic Cement: Part 5 Determination of Initial and Final Setting Times (First Revision) |
| IS:4078-1980 | Code of Practice for Indexing and Storage of Drill Cores (First Revision) |
| IS:4081-1986 | Safety Code for Blasting and Related Drilling Operations (First Revision) |
| IS:4138-1977 | Safety Code for Working in Compressed Air (First Revision) |
| IS:4260-1986 | Recommended Practice for Ultrasonic Testing of Butt Welds in Ferritic Steel (Second Revision) |
| IS:4434-1978 | Code of Practice for In-Situ Vane Shear Test for Soils (First Revision) |
| IS:4453-2009 | Subsurface Exploration by Pits, Trenches, Drifts and Shafts-Code of Practice (Second Revision) |

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| IS:4656-1968 | Specification for Form Vibrators for Concrete |
| IS:4826-1979 | Hot Dipped Galvanised Coating on Round Steel Wires (First Revision) |
| IS:4853-1982 | Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes (First Revision) |
| IS:4923-1997 | Hollow Steel Sections for Structural Use (Second Revision) |
| IS:4925-2004 | Concrete Batching and Mixing Plant-Specification (First Revision) |
| IS:4926-2003 | Ready Mixed Concrete – Code of Practice (Second Revision) |
| IS:4968-1976 (Part-1,2 &3) | Method for Subsurface Sounding for Soils |
| IS:4984-1995 | Specification for High Density Polyethylene Pipes for Potable Water Supplies (Fourth Revision) |
| IS:5334-2003 | Magnetic Particle Flaw Detection of Welds-Code of Practice (Second Revision) |
| IS:5435-1987 | General Requirements for Cold Bituminous Macadam Mixing Plants (First Revision) |
| IS:5640-1970 | Method for Determining the Aggregate Impact Value of Soft Coarse Aggregate |
| IS:6003-1983 | Specification for indented Wire for Prestressed Concrete (First Revision) |
| IS:6006-1983 | Specification for Uncoated Stress Relieved Strand for Prestressed Concrete (First Revision) |
| IS:6241-1971 | Methods of test for Determination of Stripping Value of Road Aggregates |
| IS:6603-2001 | Stainless Steel Bars and Flats - Specification (First Revision) |
| IS:6610-1972 | Specification for Heavy Washers for Steel Structures |
| IS:6639-1972 | Specification for Hexagonal Bolts for Steel Structures |
| IS:6761-1994 | Fasteners-Countersunk Head Screws with Hexagonal Socket-Specification (First Revision) |
| IS:6909-1990 | Specification for Supersulphated cement |
| IS:6911-1992 | Stainless Steel Plate, Sheet and Strip (First Revision) |
| IS:6925-1973 | Methods of Test for Determination of Water in Concrete Admixtures |
| IS:7205-1974 | Safety Code for Erection of Structural Steelwork |
| IS:7269-1974 | Numbering of Aircraft Engines, Engine Cylinders, Combustion Chambers and Direction of Rotation of Engines and Propellers |

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| IS:7273-1974 | Method of Testing Fusion Welded Joints in Aluminium and Aluminium Alloys |
| IS:7292-1974 | Code of Practice for In-Situ Determination of Rock Properties by Flat Jack |
| IS:7293-1974 | Safety Code for Working with Construction Machinery |
| IS:7307 (Part 1)-1974 | Approval Tests for Welding Procedures Part-1 Fusion Welding of Steel |
| IS:7308-1999 | Non Coniferous Logs-Specification (First Revision) |
| IS:7310(Part-1)-1974 | Approval Tests for Welders Working to Approved Welding Procedures-Part1: Fusion Welding of Steel |
| IS:7317-1993 | Code of Practice for Uniaxial Jacking Test for Deformation Modulus of Frock (First Revision) |
| IS:7573-1975 | Hockey Shoes |
| IS:7746-1991 | Code of Practice for In-Situ Shear Test on Rock (First Revision) |
| IS:7966-1976 | Specification for Dental Modelling Wax |
| IS:8500-1991 | Structural Steel- Microalloyed (Medium and High Strength Qualities)-Specification |
| IS:8812-1978 (Part1) | Methods for Chemical Analysis of Hard Solders for Jointing Aluminium and Aluminium Alloys Part 1 Determination of Silver, Copper, Zinc, Antimony, Iron and Bismuth |
| IS:8812-1982 (Part2) | Methods for Chemical Analysis of Hard Solders for Jointing Aluminium and Aluminium Alloys Part 2 Determination of Aluminium |
| IS:9000-2005 | Quality Management Systems-Fundamentals and Vocabulary (Third Revision) |
| IS:9012-1978 | Recommended Practice for Shotcreting |
| IS:9437-2008 | Specification for Fixed Precision Resistors |
| IS:9565-1995 | Acceptance Standards for Ultrasonic Inspection of Steel Castings (Second Revision) |
| IS:9595-1996 | Metal Arc Welding of Carbon and Carbon Manganese Steels –Recommendations (First Revision) |
| IS:9862-1981 | Ready Mixed Paint, Brushing, Bituminous, Black, Lead Free, Acid, Alkali, Water and Chlorine Resisting |
| IS:10433(Part 1)-1983 | Specification for Male Stud Tee Body (Stud Run) for Oil –Hydraulic Coupling- Part-1: Made form Forging |
| IS:11587-1986 | Structural Weather Resistant Steels |
| IS:12063-1987 | Classification of Degrees of Protection provided by Enclosures of Electrical Equipment |

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| IS:12089-1987 | Specification for Granulated Slag for Manufacture of Portland Slag Cement |
| IS:12119-1987 | General Requirements for Pan Mixers for Concrete |
| 1S:12269-1987 | Specification for 53 Grade Ordinary Portland Cement |
| IS:12330-1988 | Specification for Sulphate Resisting Portland Cement |
| IS:12594-1988 | Hot Dip Zinc Coating on Structural Steel Bars for Concrete Reinforcement-Specification |
| IS:13162(Part-4)-1992 | Geotextiles- Methods of Test-Part 4: Determination of Puncture Resistance by Falling Cone Method |
| IS:13162(Part-5)-1992 | Geotextiles- Methods of Test-Part 5: Determination of Tensile Properties using a Wide Width Strip |
| IS:13360-1992 | Plastics-Methods of Testing |
| IS:13620-1993 | Fusion Boned Epoxy Coated Reinforcing Bars-Specification |
| IS:13757-1993 | Burnt Clay Fly Ash Building Bricks- Specifications |
| IS:13759-1993 | Polyurethane Primer Zinc Phosphate (Two Pack) for Exterior Painting of Railway Coaches |
| IS:14293-1995 | Geotextiles- Method of Test for Trapezoid Tearing Strength |
| IS:14294-1995 | Geotextiles-Method for Determination of Apparent Opening Size by Dry Sieving Technique |
| IS:14324-1995 | Geotextiles –Methods of Test for Determination of Water Permeability-Permittivity |
| IS:14589-1999 | Zinc Priming Paint, Epoxy Based Two Pack-Specification |
| IS:14700 (Part 6 Sec 3) | Electromagnetic Compatibility (EMC)- Part 6 Generic Standards- Sec 3: Emission Standards for Residential, Commercial and Light Industrial Environments |
| IS:14925-2001 | Epoxy Resin for Paints-Specification |
| IS:15284 (Part 1)-2003 | Design and Construction for Ground Improvement-Guidelines: Part 1 Stone Columns |
| (Part 2)-2004 | Design and Construction for Ground Improvement-Guidelines: Part 2 Preconsolidation using Vertical Drains |
| IS:15388-2003 | Silica Fume-Specification |
| IS:15462-2004 | Polymer and Rubber Modified Bitumen-Specification |
| IS:15809-2008 | High Visibility Warning Clothes-Specification |
| IS:SP:23-1982 | Handbook on Concrete Mixes (Based on Indian Standards) |

## (B) FOREIGN STANDARDS

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| ASTM E8 | Standard Test Methods for Tension Testing of Metallic Materials |
| ASTM-E:11 | Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves |
| ASTM 36 | Standard Specification for Carbon Structural Steel |
| ASTM-D:297 | Standard Test Methods for Rubber Products-Chemical Analysis |
| ASTM-C:309-81, | Standard Practice Standard Specification for Architectural Flat Glass Clad Polycarbonate |
| ASTM 393 | Standard Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure |
| ASTM-D:412 | Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension |
| ASTM-D: 471 | Standard Test Method for Rubber Property-Effect of Liquids |
| ASTM-D:573 | Standard Test Method for Rubber-Deterioration in an Air Oven |
| ASTM 711 | Standard Specification for Steel Forging Stock |
| ASTM 732 | Standard Specification for Castings, Investment, Carbon and Low Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures |
| ASTM 788 | Standard Specification for Steel Forgings, General Requirements |
| ASTM-E:809 | Standard Practice for Measuring Photometric Characteristics of Retro-reflectors |
| ASTM-E:810 | Standard Test Method for Coefficient of Retro-reflection of Retro-reflective Sheeting Utilizing the Coplanar Geometry |
| ASTM-D:903 | Standard Test Method for Peel or Stripping Strength of Adhesive Bonds |
| ASTM 968 | Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive |
| ASTM-D:1149 | Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment |
| ASTM 1264 | Standard Classification for Acoustical Ceiling Products |
| ASTM 1475 | Standard Test Method For Density of Liquid Coatings, Inks, and related Products |
| ASTM-D:1505 | Standard Test Method for Density of Plastics by the Density-Gradient Technique |
| ASTM-F:1553-06 | Standard Guide for Specifying Chain Link Fence |

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| ASTM 1644 | Standard Test Methods for Non-volatile Content of Varnishes |
| ASTM-F:1647-11 | Standard Test Methods for Organic Matter Content of Athletic Field Rootzone Mixes |
| ASTM-D:1693 | Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics |
| ASTM-D:2041 | Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures |
| ASTM 2172 | Standard Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures |
| ASTM-D:2240 | Standard Test Method for Rubber Property-Durometer Hardness |
| ASTM-D:2628 | Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements. |
| ASTM-D:2990 | Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics |
| ASTM-D:3776 | Standard Test Methods for Mass Per Unit Area (Weight) of Fabric |
| ASTM-D:3786 | Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method |
| ASTM-D:4060 | Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser |
| ASTM 4280 | Standard Specification for Extended Life Type, Non-plowable, Raised Retro-reflective Pavement Markers |
| ASTM-D:4491 | Standard Test Methods for Water Permeability of Geotextiles by Permittivity |
| ASTM-D:4533 | Standard Test Method for Trapezoid Tearing Strength of Geotextiles |
| ASTM-D:4595 | Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method |
| ASTM-D:4632 | Standard Test Method for Grab Breaking Load and Elongation of Geotextiles |
| ASTM-D:4716 | Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head |
| ASTM-D:4751 | Standard Test Method for Determining Apparent Opening Size of a Geotextile |
| ASTM-D:4873 | Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples |
| ASTM-D:4956 | Standard Specification for Retro-reflective Sheeting for Traffic Control |

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